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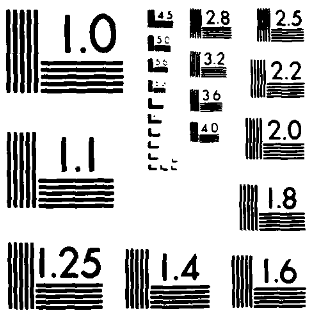

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FINAL

CONTRACTOR PRODUCTIVITY MEASUREMENT

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FINAL

CONTRACTOR PRODUCTIVITY MEASUREMENT

by

Monte G. Norton

Wayne V. Zabel

The pronouns "he," "his," and "him," when used in this publication represent both the masculine and feminine genders unless otherwise specifically stated.

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EXECUTIVE SUMMARY

A. BACKGROUND. The cost of producing weapon systems with the current defense industrial base continues to escalate. In addition, the deteriorated condition of the base has prompted increased concern over its capability to respond to mobilization requirements. The recognition of these problems led to the initiation of a DOD Industrial Modernization Incentives Program (IMIP) which targets industry through incentives to substantially increase its capital investments with its own financing in modern technology, plant and equipment for defense work. A requisite for productivity rewards from these incentives is the ability to accurately measure and track a contractor's productivity gains.

B. STUDY OBJECTIVES. The objective of this study is to develop and test measurement systems which (1) are designed to complement IMIP by providing a productivity measurement and tracking system and, (2) may provide a basis for contract incentives to motivate contractors to improve their productivity through methods changes, management improvements and other means in addition to capital investment.

C. STUDY APPROACH. All military services are participating in this DOD study. Defense contractors are also involved in system development through a survey of contractor productivity measurement practices. A thorough investigation of productivity measurement theory was conducted by an independent contractor. From an analysis of the theory investigation and survey responses, productivity measurement methodologies were identified. The methodologies proposed for IMIP will be tested, and if warranted, an implementation guide supporting the IMIP will be prepared.

D. CONCLUSIONS AND RECOMMENDATIONS. This final report describes the results of a survey of defense contractor productivity measurement practices and identifies a number of techniques available to measure productivity and to help bring about required improvements. Contractors responding to the survey ranked productivity fifth in importance as a performance evaluation factor after profitability, effectiveness, quality, and efficiency. While any of the techniques identified can be, and should be used by contractors to improve their productivity, only three should be tested for direct application in IMIP.

It is recommended that the following measurement techniques be tested in a defense contractor environment: (1) Multi Factor Productivity Measurement Model (MFPMM), (2) the Cost Benefit Analysis/Cost Benefit Tracking (CBA/T) methodology, and (3) the shared savings techniques. In addition, it is recommended that criteria similar to C/SCS criteria be established to provide the basis for determining whether a contractor's productivity measurement system is acceptable.

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CHAPTER I

INTRODUCTION

A. BACKGROUND/PROBLEM.

As shown in recent APRO studies and other investigations, productivity in the defense industry can be and needs to be improved. The cost of producing weapon systems with the current industrial base continues to escalate. In addition, the deteriorated condition of the defense industrial base has prompted increased concern over its capability to respond to mobilization requirements. Productivity improvements are required before solutions to these persistent problems can be realisitically expected.

Many factors have contributed to the declining productivity growth within the defense industry. The general economic environment in the US has not provided the environment required for modernization investments. Inflationary periods permit passing on price increases due to inefficiencies as well as those due to decreased productivity or increased inflation. High interest rates and federal tax policies can further inhibit capital investments. Also, excessive short-run thinking in business decisions has neglected productivity where investments typically bring mid to long-run paybacks.

Initiative Number 5 of the Acquisition Improvement Program was directed at encouraging capital investment to enhance productivity. In addition to contract financing improvements, several productivity actions have emanated from the spirit of the Acquisition Improvement Program. A newly established Industrial Productivity Directorate within OSD has the responsibility of providing leadership in the productivity area. They serve as a focal point, facilitator, and advocate on productivity issues. Also, a DOD Industrial Modernization Incentives Program (IMIP) was initiated which targets industry through incentives to substantially increase its capital investments with its own financing in modern technology, plant and equipment for defense work. Such investments will contribute to productivity growth, reductions in the cost of producing end items, and an improved industrial base.

A requisite for productivity rewards is the ability to accurately measure and track a contractor's productivity gains. At present, contractor efficiency and productivity cannot be readily measured and related to a contract. A practical method of measuring productivity and effecting rewards must be developed to stimulate improved productivity. Development of a methodology for productivity measurement is of importance if certain types of incentives are to be employed. This effort will support the IMIP.

B. STUDY SCOPE.

This study is looking at ways of measuring contractor productivity and relationships between possible measurement techniques and associated potential productivity incentives. Alternatives for measuring productivity, the type of productivity data needed, the type of data currently available, and the degree to which the data would be verifiable and suitable as a basis for appropriate contract incentives are being explored. The study will also look at proposed incentives from the standpoint of productivity related information needed to support the incentives.

C. STUDY OBJECTIVE.

The development of a productivity measurement methodology constitutes a major effort addressing such issues as specific definitions of contractor productivity and its measurement. The objective of this study is to develop and test measurement systems which (1) are designed to complement IMIP by providing a productivity measurement and tracking system and, (2) may provide a basis for contract incentives to motivate contractors to improve their productivity through methods changes, management improvements and other means in addition to capital investment. Specific subobjectives proposed to accomplish this are:

1. Develop specific definitions of contractor productivity appropriate for the products concerned and the contracts involved.

2. Design measurement techniques that allow for establishing a baseline, tracking performance, and showing auditable results.

3. Relate these measurement techniques to incentives and reward mechanisms.

4. Synthesize the definitions, measurement techniques and reward mechanisms.

5. Test the proposed methodology on representative contracts and contractors to determine the suitability for DOD implementation.

6. Based upon the test results, recommend DOD policy and procedure coverage, as appropriate.

D. STUDY APPROACH.

A study that addresses defense contractor productivity measurement is a high-risk effort in terms of probability of success, but it has tremendous potential benefits to be shared by all. To reduce the risks and improve the probability of success, top-level management within DOD and each of the military services has supported this effort. To improve the chances for system acceptance and to establish credibility throughout the defense community, DOD and the defense contractors have been involved in system development.

The study team for this DOD effort supporting IMIP included representatives from the following organizations: Defense Systems Management College (DSMC), Army Procurement Research Office (APRO), Naval Office for Acquisition Research

(NOAR) and Air Force Business Research Mangement Center (AFBRMC). The representatives shared the responsibility for completing the following actions to meet the study objectives:

1. Review pertinent literature and current policy relating to productivity.

2. Design a contractor survey and distribute it to defense contractors through an industry association.

3. Analyze literature and survey responses.

4. Contact Government personnel in those functional areas impacting productivity measurement for insights into relationships.

5. Visit selected contractors responding to the survey for detailed follow-up discussions.

6. Synthesize proposed productivity measurement methodology based upon analyses and findings.

7. Design test plan.

8. Conduct test.

9. If warranted, develop implementation guide.

Not all of the above actions have been completed. This final report describes the results of investigations into productivity theory and practices, a taxonomy for productivity measurement techniques, measurement techniques and their applications, implications for IMIP and draws conclusions and recommendations. A test of measurement techniques is being considered as a follow-on to this effort. A separate report will be published to record the results of any such activity.

CHAPTER II

PRODUCTIVITY MEASUREMENT THEORY

A. INTRODUCTION.

Productivity measurement theory serves as the foundation for the development of techniques and methodologies for application within DOD. The theory provides the necessary definitions and organization that allow communication and understanding of the concepts involved and their interrelationships. Therefore an early investigation of current theory was in order.

Productivity is first defined in this chapter and then placed in a construct that relates it to other performance factors such as effectiveness and profitability which are also of concern to defense contractors and DOD managers.

Most of the information in this chapter was extracted from a report prepared under contract for this project by Dr. Scott Sink, Oklahoma Productivity Center, and Dr. Thomas Tuttle, Maryland Center for Productivity and Quality of Working Life. Their report provides considerably more detail and discussion than that presented here and should be referred to if more detail is needed (Sink and Tuttle, 1983).

B. DEFINITIONS.

Productivity takes on many different meanings to different people. To establish a common understanding of the concept of productivity and its relationship to other performance measures, definitions are necessary.

In general, there are at least seven distinct although not necessarily mutually exclusive measures of organizational systems performance. The are: (1) effectiveness, (2) efficiency, (3) quality, (4) productivity, (5) quality of work life, (6) innovation, and (7) profitability. These seven performance measures or criteria are defined below.

1. Effectiveness = Accomplishment of Purpose (Barnard 1938). Accomplishing the "right" things: (1) on time, (i.e., Timeliness); (2) right, (i.e., Quality); (3) all the "right" things, (i.e., Quantity) where "things" are goals, objectives, activities, etc.

2. Efficiency = (a) Satisfying individual motives, (Barnard, 1938), success at securing necessary personal contributions.
(b) $\dfrac{\text{Resources Expected to be Consumed}}{\text{Resources Actually Consumed}}$

3. Quality = Conformance to specifications, (Crosby, fitness for use.) where "specifications" can be identified as: timeliness, various quality attributes, customer satisfaction, etc.

4. Productivity = $\dfrac{\text{Quantities of Output from an Organizational System for some period of time}}{\text{Quantities of Input Resources Consumed by that Organizational System for that same period of time}}$

or

$$\frac{\text{Quality Quantity}}{\text{Resources Actually Consumed}}$$

Hence, productivity is, by definition, a ratio and is a measure of effectiveness in the numerator divided by the denominator of the efficiency equation. Quite often productivity statistics for the nation are presented in terms of rates of change. These statistics are actually productivity indexes. A productivity index is a particular productivity ratio for one period of time divided by that same productivity ratio for an earlier period of time. For example:

$$\text{Productivity Index} = \frac{\dfrac{\text{Quality Quantity 1982}}{\text{Resources Actually Consumed 1982}}}{\dfrac{\text{Quality Quantity 1981}}{\text{Resources Actually Consumed 1981}}}$$

or, rate of change of GNP to labor input, etc.

5. Quality of Work Life = Human being's affective response to working in and living in organizational systems. Those attributes of organizational systems that "cause" positive affective responses. Often the focus is on ensuring the employees are "satisfied," safe, secure, etc.

6. Innovation = The creative process of adaption of product, service, process, structure, etc., in response to internal as well as external pressures, demands, changes, needs, etc. The process of maintaining fitness for use from the customer's eyes.

7. Profitability = A measure or set of measures of the relationship between financial resources and uses for those financial resources. For example, Revenues/Costs, Return on Assets, and Return on Investments

Figure 2.1 compares this conceptualization with two others: (a) Drucker (1953) and (b) Peters and Waterman (1982).

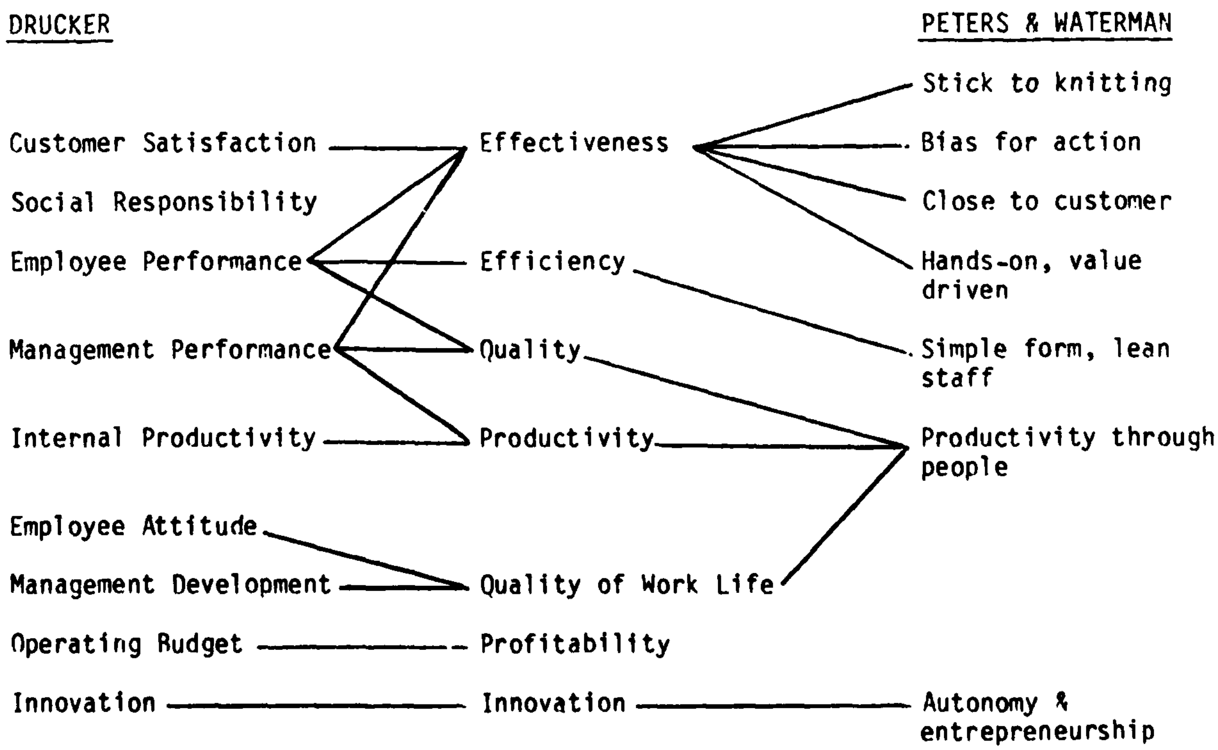

FIGURE 2.1 ORGANIZATIONAL SYSTEMS PERFORMANCE CRITERIA

Productivity is only one measure of performance for a given system. It is not clear if it is necessarily the most important or even necessarily a critical measure of performance for all systems. The problem in designing a control system is a multi-attribute or multi-criteria one.

In one respect, one important job of a manager is to determine: (1) what the appropriate priorities or relative weights are for each performance measure; (2) how to measure, operationally, each performance measure; and (3) how to link the measurement system to improvement (in other words, how to most effectively use the control system to cause appropriate changes or improvements). It is reasonably clear that the priorities or weightings for each of these performance criteria will vary according to several factors: (1) size of the system, (2) function or objectives of the system, (3) type of system (technology employed) - i.e., job shop, assembly line, service, process, etc., (4) maturity of the system in terms of management, employees, technology, organizational structure and processes, and (5) the environment (political, economic, and social) characteristics.

C. PRODUCTIVITY MANAGEMENT.

Productivity is a relationship (usually a ratio or an index) of output (goods and/or services) produced by a given organizational system and quantities of inputs (resources) utilized by that same organizational system to produce that same output. As can be seen, it is a very simple concept. One can take what a given organizational system produces or creates, quantify it, and put it in the numerator of an equation. Then the specific resources (labor, capital, materials, and/or energy) utilized to create those outputs are put in the denominator of the equation. The results is an operational measure of the concept productivity. It seems so simple and easy, and often it is. For instance, if an organizational system has clearly measurable outputs and identifiable and measurable inputs that can be matched temporarily to the production of outputs (i.e., reasonably short cycle times) productivity measurement is quite routine. There are models and programs available that will even extrapolate the ratios.

However, if, as is often the case, outputs are somewhat hard to measure, input resource utilization is hard to match up with outputs for a given period of time, input and output quality is inconsistent, input and output mix or type is constantly changing, data is either difficult to obtain or is not even available, etc., etc..,then productivity measurement can become difficult and frustrating. These factors contributing to making productivity measurement difficult do not consider the appropriateness of productivity as a criteria for organizational systems performance. Nor does it consider the specific relative weighting or importance to be given to productivity as a performance criteria. Assuming productivity were viewed as being important, the point to be made is that in some cases the process of productivity measurement is relatively easy and techniques are established while in many other cases the process can be relatively difficult and techniques are not well established.

As a mechanism for simplifying and making the presentation of productivity basics more efficient, Figure 2.2 has been developed. This illustration depicts the basic productivity management process. It incorporates definitions and concepts presented to this point. Starting at the top of the figure, the planning decision process is denoted by the diamond shaped symbol. Directly beneath is a basic systems flow model for an organizational system. Input variables flow into the system, are transformed into new states represented by

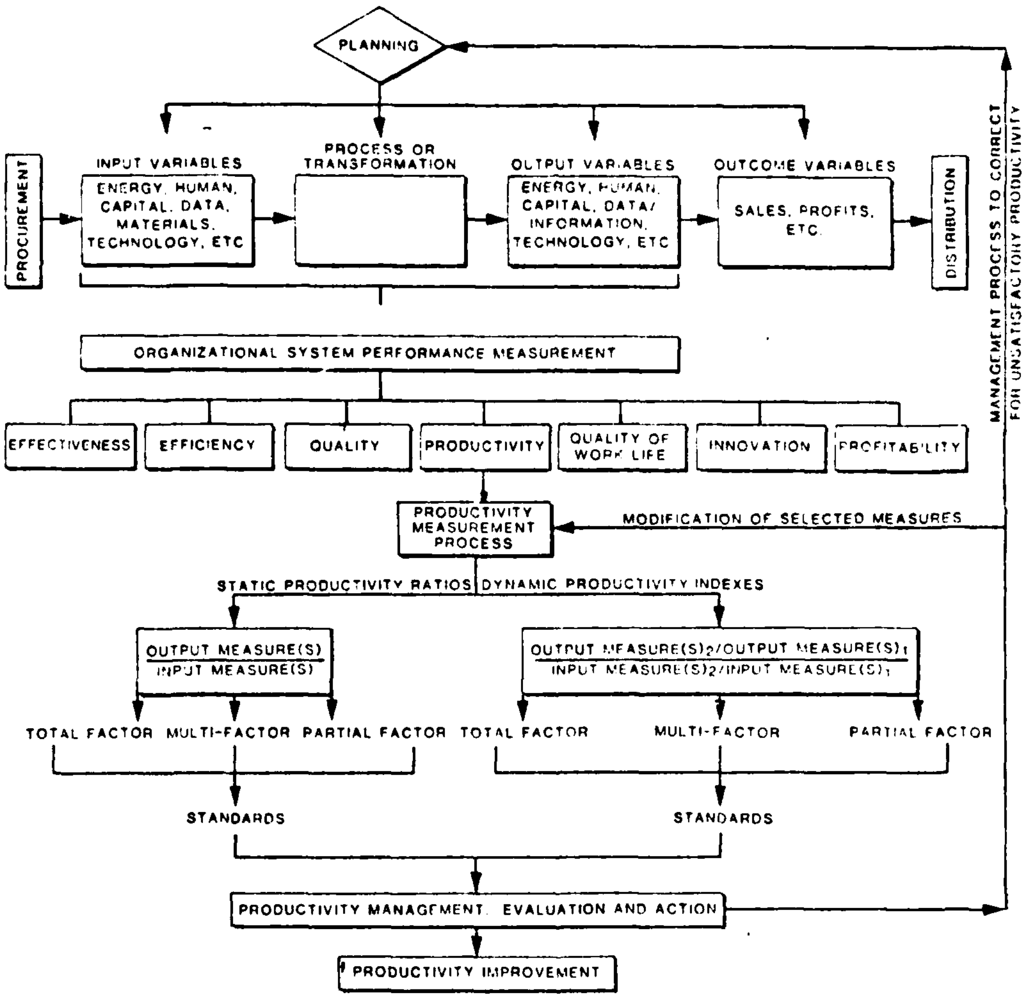

FIGURE 2.2 PRODUCTIVITY MANAGEMENT PROCESS

goods and/or services which are outputs, and these outputs are then delivered to "customers". The input variables are procured by some "procurement function" and as such carry with them quality, quantity, and financial attributes. That is, the input variables or resources come into the organizational system with specific "price tags", with certain quality characteristics, and in specific volumes or quantities. The transformation process(es) can be treated as a "black box," keeping in mind that particularly for productivity improvement there is a need to make the "black box" a "glass box". That is, one needs to understand and analyze specific transformations in order to improve productivity.

Output variables, or transformed input variables, also carry with them quality, quantity, and financial attributes. That is, the output(s) (goods and/or services), have associated levels of quality, have "price tags", and come out in specific volumes and quantities. Outcome variables reflect the results achieved after the output has been successfully distributed to "customers" (i.e., sales, profits, customer satisfaction, etc.). It is particularly important not to confuse outcomes with outputs. Persons in the organizational system have control over the attributes of the output, however, they often lack control over outcomes. Definitions must be kept clearly in focus.

This input-transformation process output-outcome model can, of course, be made to conceptually represent any size, type, or kind of organizational system. For instance, it can represent a plant, typing pool, office, department, or any other organizational system depending upon how the boundaries of the system are defined and hence the "unit of analysis". As has been mentioned, organizational system performance measurement can be operationalized utilizing some combination of the seven performance criteria. In particular, the focus of this chapter is on the role productivity plays in overall performance. As can be seen on Figure 2.2 the productivity measurement process branches down in the lower third of that figure.

D. PRODUCTIVITY MEASURES.

Conceptually, at least, there are four basic types of productivity measures. Static productivity ratios and dynamic productivity indexes are the major categories of productivity measures. Per the delimited definition, productivity is basically a ratio of output measures to input measures. If all the output and all the input from given organizational systems gets into the equation then we have a total factor, static productivity ratio. If some or all of the output and only some of the input gets into the equations then we have a partial factor, static productivity ratio. These ratios are called static because they are like a snapshot. For instance, a snapshot is taken of what happened in July 1983 for a given plant and the ratio(s) are constructed from that snapshot.

The other basic measure of productivity is what is called a "dynamic productivity index." Again, if all of the outputs and all of the inputs from a given organizational system get into the equation and then static productivity ratios are compared from one period (say a base period) to current productivity ratios, this yields a total factor, dynamic productivity index. If however, and for whatever reason, all or only some of the outputs and only some of the inputs are captured in the two ratios, this yields a partial factor, dynamic productivity index. For example,

$$\text{Dynamic Productivity Index} = \frac{\dfrac{\text{Outputs 1983}}{\text{Inputs 1983}}}{\dfrac{\text{Outputs 1978}}{\text{Inputs 1978}}}$$

Referring to Figure 2.2 once again, after the productivity measurement process is completed, data can be collected and management can begin to get a feel for the range and variability of the numbers. Standards can be established using norms (industry or internal), engineered methods, historical data, etc.

The productivity improvement process in its simplest form is one of evaluation of productivity data and planning managed interventions on the organizational system that are expected (cause and effect beliefs) to improve productivity and eventually other performance measures. In most cases, today's managers are simply evaluating performance data, not necessarily productivity data. Many managers confuse and muddy the waters in respect to productivity because they do not delineate carefully differences between productivity definitions, performance concepts, productivity measurement, performance measurement, productivity improvement, performance improvements, etc.

Productivity, as mentioned, is strictly a relationship between resources that come into an organizational system over a given period of time and outputs generated with those resources over the same period in time. It is most simply Output/Input. As discussed, productivity implicitly is therefore a relationship between the effectiveness of a system during a given period of time (i.e., accomplishment of the "right" things) and resources consumed to accomplish those "right" things. It does not tell everything wanted or needed regarding the overall performance of a given organizational system. It gives only part of the picture, albeit an important piece of the picture.

Productivity measurement and evaluation is the process by which we operationalize this definition of productivity. Measures (ratios and/or indexes) of output to input for given organizational systems are created. Those measures, if developed correctly and if tracked over time so as to establish standards or expectations, can provide useful management with which to develop plans for effective and efficient productivity control and improvement.

> "Without productivity objectives, a business does not have direction. Without productivity measurement, it does not have control."
>
> -Peter Drucker

CHAPTER III

CONTRACTOR PRODUCTIVITY MEASUREMENT PRACTICES

A. INTRODUCTION.

A requisite for productivity rewards is the ability to accurately measure and track a contractor's productivity gains. To be useful to the IMIP, a measurement methodology must not only be based on sound theory but also be implementable. Therefore, an examination of productivity measurement practices is a necessary complement to an investigation of productivity measurement theory.

Since Defense contractors have always measured their productivity, directly or indirectly, they are an important source of information for this study. Their experiences are useful in understanding both what is currently being practiced and what has been tried with varying success. Expanding on an earlier survey of major corporations (Sumanth and Erinspruch, 1980) which showed a dominance of partial productivity measures at all organizational levels, a written survey was used to contact a large sample of defense contractors. The survey not only helped identify current performance measurement practices but also allowed defense contractors an opportunity to participate in an effort that could eventually affect them. Contractor participation was considered important to a successful implementation of any proposed methodologies. The National Security Industrial Association (NSIA) was solicited and agreed to participate in a survey of some of its member companies.

B. SURVEY DESCRIPTION.

The primary purpose of the survey was to obtain information about productivity measurement methodologies currently employed by defense contractors. It also opened doors for follow-up discussions by asking for points-of-contact. The survey was not intended to provide an elaborate description or classification of current practices. A copy of the survey and NSIA cover letter is provided in the Appendix.

The survey was sent to 92 different contractor locations. Table 3.1 lists the 21 respondents to the survey.

1. Remington Arms - Bridgeport, CT
2. AVCO - Bridgeport, CT
3. Sperry - Waterbury, CT
4. United Technologies - Hartford, CT
5. EG&G Sealog - Warwick, RI
6. Hazeltine - Greenlawn, NY
7. Westinghouse - Columbia, MD
8. Western Electric - Burlington, NC
9. Martin Orlando - Orlando, FL
10. Sparton Corp - Deleon Springs, FL
11. Harris Corp. - Melbourne, FL
12. Northrop Corp. - Los Angeles, CA
13. Rockwell Int'l - Canoga Park, CA
14. McDonald-Douglas - Huntington Beach, CA
15. Ford Aerospace - Newport Beach, CA
16. Ball Aerospace - Boulder, CO
17. Ingalls Shipbuilding - Pascagoula, MS
18. Magnavox - Ft. Wayne, IN
19. Goodyear Aerospace - Akron, OH
20. Honeywell - Edina, MN
21. Anonymous

TABLE 3.1. CONTRACTORS RESPONDING TO SURVEY

Follow-up discussions were then held with 14 of those that responded. The number responding was less than desired but adequate to gain an understanding of current practices. The relatively low response rate can be attributed to a general reluctance to participate in any survey and, perhaps, inattention to productivity measurement concepts per se in the defense community prior to the IMIP. This inattention to productivity measurement cannot be confined solely to the defense community when one considers the following quotation of Dr.

Scott Sink who conducts a short course on the productivity. "I am convinced as a result of my interaction with over 500 managers in the last three years that productivity, strictly defined, is absent from at least 95% of the control systems in American organizations."(Sink and Tuttle, 1983) Even for those contractors responding, productivity factors were ranked low (usually fifth) relative to other measures of organizational performance asked for in the survey (see Figure 3.1).

C. SURVEY RESPONSES.

1. General Information. All commodity markets were represented by the responding contractors with electronics and communications equipment being the dominant market. The contractors involvement as prime, subcontractor or both was roughly balanced among those three choices. The dollar value of their defense contracts during their latest accounting year ranged from $.6M to $4.3B and averaged roughly $500.M. The contractors worked predominantly for the Navy, but all services were represented by the respondents.

2. Performance Evaluation. Question B.1 (shown below) of the survey asked contractors to rank their measures of organizational performance.

B. PERFORMANCE EVALUATION (at profit center level or above):

1. Which of the following factors do you use to measure organizational performance within your company? (Indicate order of relative importance to your company, e.g., 1, 2, 3 . . .)

_____ (a) Effectiveness (i.e., accomplishing the right goals or objectives considering timeliness, quantity, and quality)

_____ (b) Efficiency (i.e., ratio of resources expected to be consumed on goal achievement to resources actually consumed)

_____ (c) Quality (i.e., conformance to specifications)

_____ (d) Profitability (i.e., comparison of revenues to costs)

_____ (e) Productivity (i.e., ratio of output to input)

_____ (f) Quality of Working Life (i.e., personnel response to living and working in organization)

_____ (g) Innovation (i.e., introducing new ideas, processes, or products)

_____ (h) Other - (Please specify) ____________________

Figure 3.1 shows the contractor rankings of these performance evaluation factors. Profitablility was consistently ranked most important by the respondents. Effectiveness and quality were ranked next, respectively, in importance. Productivity, when used, was usually ranked fifth.

PERFORMANCE FACTOR	CONTRACTOR																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
a. Effectiveness	2	3	1	1	3	3	4	1	2	7	1	3	2	4	2	2	1		2
b. Efficiency			3	2		2	5		3	4	4	5	5	5	7	3	3	2	1
c. Quality	4	2	2	2	2		3	3	4	2	3	6	4	2	4	4	2	3	3
d. Profitability	1	1	4	2	1	1	1	2	1	1	2	1	1	1	1	1	5	1	4
e. Productivity	5		5	2		5	6	4	5	3	5	7	3	3	3	5	6		
f. QOWL	6		6	2		6		5		6		4	6	7	5	7	7		6
g. Innovation	3	5	7	2		4	2			5		2	7	6	6	6	4		5
h. Other		4		1	4										8				

FIGURE 3.1. CONTRACTOR RANKINGS OF PERFORMANCE EVALUATION FACTORS

(Note: The contractor order here has no relationship to the Table 3.1 list.)

The only problems identified by the respondents using the above performance factors were:

a. performance measures did not connect with productivity

b. short term was wrong emphasis

c. comparisons between time periods can be influenced by extraneous factors foreign to what is being measured.

3. Productivity Measurement. The productivity measures used by defense contractors varied according to the organizational level being measured. For example, a value added type of index such as value added/employee was frequently used at the firm level. Efficiency measures such as the ratio of standard time/actual time were also used by some to judge productivity at the firm level. Other firm level indicators used included value added/capital, sales/assets, profit/employees, and direct employees/indirect employees.

Although the efficiency ratio of standard time/actual time was used on occasion to judge firm or factor productivity, it was more frequently used at the department or shop level. Generally at this level performance ratios such as inspectors/production workers or units scheduled/units produced were used to measure productivity. Physical units of production were also compared to various labor and capital inputs at this level for true productivity measurement. These include, for example, purchase orders/and engineering change orders/engineer.

Subordinate activites or work centers frequently compared some specific output to labor input. Examples at this level include cables/labor hour or printed circuit boards produced/labor hour. Comparison of standard hours to actual hours for work performed was also popular at the work center level.

Data sources for productivity measures also varied widely depending on the specific indices used. Accounting, personnel, production and labor hour data were used as appropriate. Adjustments for inflation and learning curve effects were often made to productivity information, but discounting and quality changes were usually not incorporated.

Validation efforts ranged from virtually no effort to implementing changes in production standards. Usually validation was minimal since internal review mechanisms were not as rigid or strict as would be required for an external audit.

Those with experience in productivity measurement encountered problems of varying degrees in attempting its measurement. Some of the problems reported include:

a. difficulty in isolating cause of improvement above plant level because of many variables

b. qualitative factors influencing productivity difficult to measure

c. difficulty in aggregating data for government accounting on a job-by-job basis while productivity measures require an overall accounting

d. difficulty in quantifying output because of large number and complexity of projects

e. present methods not applicable to white collar area which is 75% of work force

f. difficulty in measuring productivity impacts in other organizational areas

g. timeliness, accuracy, insufficient detail and difficulty in analyzing the data

h. costly to apply, requires computer support, has limited coverage (production operations only)

i. many measurements deal with symptoms, not causes

4. General Comments. Question D.1 of the survey asked:

> If the Government were to offer your company a productivity incentive in a new contract, how would you prefer to have your productivity improvements measured?

Responses included the following:

a. value added/employee

b. cost savings

c. no change in present method being used by company

d. cost reduction relative to a baseline, adjusted for inflation

e. track measurable changes in safety, quality and productivity output in finished good per man-hour of input

f. simple comparison of target cost to actual cost

g. unit production labor hours

h. simple profit rate increases

i. compare new systems to existing systems

j. estimate savings prior to change then increase profit accordingly

k. traditional measures of cost, schedule and performance

l. quality measurement should be used

m. in terms of total factory cost by product.

These responses indicate a desire to keep productivity measurement simple and to base the award on the cost difference between a baseline and achieved cost, adjusted for inflation.

D. SURVEY AND DISCUSSION FINDINGS.

1. Production Cost Visibility.

Production cost visibility and related productivity measurement varied widely among those contractors visited. Most contractors relied primarily upon general profitability information gathered from balance sheets and profit or loss statements of financial accounting; or cost element data from standard cost accounting systems governed by Generally Accepted Accounting Principles (GAAP) or Uniform Cost Accounting Standards (CAS) as detailed in Federal Acquisition Regulation (FAR) Part 30 and DOD FAR Supplement, Appendix O. Others had sophisticated management information systems (MIS) to capture costs and productivity information in detail at work centers throughout their plants. This allowed tracking a large number and variety of productivity related indices in functional areas in addition to production such as engineering, procurement, and accounting.

2. Direct Costs.

All contractors visited could provide direct labor and material costs through work center tracking. Indirect costs were also available, and overhead rates were calculated and applied to direct costs to get their total cost figures. Unfortunately, direct costs constitute a small and decreasing percentage of total cost, and therefore are becoming less useful as the sole basis for productivity measurement. Indirect costs are substantial and must also be addressed in productivity measurement. For example, direct labor typically amounted to less than 10% of the total cost and is decreasing regularly with the advent of automation and robotics. Table 3.2, extracted from the Air Force PACER PRICE program, shows average direct labor rates for spare parts production varying from 8% to 17% depending upon the capital/labor mix.

It also shows the tremendous increase in manufacturing overhead and other indirect rates as the capital/labor mix increases from low to high.

3. Productivity and Other Indices.

Productivity information is readily available to all contractors, but some are just beginning to track specific productivity indices. Value added per employee was frequently used as an overall indicator of plant or company productivity; however, no single index is adequate for all contractor purposes. The value added per employee index is useful for contractor purposes in comparisons among plants or companies within an industry.

There was no evidence of a total factor productivity measurement system implemented by the survey respondents, although some were attempting to implement one. Multiple indices were often used; however, they were not integrated as required in a total factor approach. Frequently, other productivity related indices were used for particular purposes in different departments such as rework hours/direct labor hours, cost of quality/cost of sales, and indirect employees/direct employees. These ratios are not productivity indices per se (using the standard output/input definition) but were useful in measuring and analyzing performance.

4. Tracking Impacts.

Defense contractors know the costs of operating current capital equipment, and they can give a reasonable cost estimate for an investment in new capital equipment. The impact of this new equipment on direct labor and materials is also usually apparent. However, tracking the impact of an investment for productivity improvement in the indirect area gets obscured, and these costs usually increase with a decrease in direct costs. For example, programming support costs for a new numerical control milling machine may get buried

	HIGH	HIGH-MIDDLE	LOW-MIDDLE	LOW
MANUFACTURING OVERHEAD	343%	231%	189%	112%
OTHER INDIRECT COSTS	36.7%	33.2%	21.9%	14.0%
PROFIT	12.3%	12.8%	13.0%	13.4%
CAS-414	2.1%	1.8%	1.5%	1.2%
ECONOMIC IMPACT RATING	3.161	3.165	2.894	2.977
LEARNING CURVE	98%	96%	92%	84%
DIRECT MATERIAL	27%	24%	24%	21%
DIRECT LABOR	8%	13%	14%	17%
MANUFACTURING HOURLY RATE	12.41	11.48	11.35	10.82

TABLE 3.2 PACER PRICE RATE APPLICATION RATES
(SOURCE: PROCEEDINGS OF AFLC PACER PRICE CONFERENCE, 3-4 AUG 83)

in the ADP department, or maintenance increases for new robots may get lost since its impact appears negligible. Also, a new automated MIS acquired specifically to provide a degree of cost control not previously possible may also be used for inventory control, financial accounting, and personnel management. Proper allocation among functions is difficult but may be necessary for DOD productivity measurement purposes.

The multiple product, plant and customer environment found at most contractors visited further inhibits accurate cost tracking for productivity measurement. A single plant, single product environment provided relatively easy assessment of productivity improvements for DOD purposes.

5. Follow-up Verifications.

Partly because of the difficulty in tracking the impact of investments in productivity enhancing equipment, the follow-up verification of productivity gains were not rigorous. Although some companies did review an investment at a later date (e.g., one year), the evidence of savings was frequently soft and judgmental. Improvements were accepted intuitively because it was obvious that more goods were produced faster and cheaper at the work center level. Neither the direct nor indirect impact on other areas within the company were readily identifiable or quantifiable.

6. Investment Purposes.

It appeared that investments were mostly for competitive and technological reasons rather than simply for cost reduction. Contractors tended to plan ahead for further contracts, products and capacity and make investments accordingly to improve their long term situation. Contractors also replaced older equipment that could not keep tolerances or required quality levels. Immediate cost improvement was secondary. Sometimes both immediate and long term benefits were realized in an investment, but the long term payoff was primary.

CHAPTER IV

TAXONOMY FOR PRODUCTIVITY MEASUREMENT TECHNIQUES

A. INTRODUCTION.

One objective of this project was to provide a taxonomy with which to categorize the productivity measurement techniques identified during the research. This chapter describes the development process and the resulting taxonomy. The taxonomy is functional in addition to descriptive in that it assists a manager in selecting the appropriate measurement technique based on requirements. The available measurement techniques are presented in Chapter V using this taxonomy.

As in Chapter II, the material in this chapter is extracted from the report prepared under contract for this project by Sink and Tuttle (1983). Their report should be referred to if more detail is desired.

B. TAXONOMY DEVELOPMENT.

Two assumptions made by the researchers steered the taxonomy development process. One assumption was to adopt a narrow definition of productivity as described in Chapter II. Therefore, adopting this narrow definition of productivity rules out consideration of other performance dimensions such as efficiency, effectiveness, or quality from the taxonomy. Thus, the taxonomy development centered on productivity measurement, not performance measurement. Developing a taxonomy of performance measurement was far beyond the scope of this activity. Other writers have developed taxonomies in these areas. Tuttle (1981) describes an approach to classifying productivity measures which adopts a broader definition of productivity. Taxonomies of organizational effectiveness measures have been proposed by Price (1968); Campbell, Bownas, Peterson & Dunnette (1974) and Mahoney & Frost (1974). A classification of quality measurement strategies has been proposed by Adam, Hershauer and Ruch (1978).

A second assumption which guided the taxonomy development process was the taxonomy should have functional value rather than simply descriptive value. The researcher concluded that the taxonomy of productivity measurement theories and techniques should have functional utility for a manager who wanted to select a productivity measurement method or technique. Therefore, if the manager could define certain parameters, the taxonomy should point to one or more techniques which correspond to the parameters (e.g., organizational level, etc.). A descriptive taxonomy on the other hand would not necessarily be as concerned with utility. It would give more concern to accuracy and precision of classification. In the domain of productivity measurement, which is poorly defined, such a descriptive taxonomy would most likely be more complex, and have more dimensions than would a functional taxonomy which would lean toward greater simplicity and ease of use.

Given these two assumptions, the researcher considered a wide range of possible dimensions which could be used to classify productivity measurement techniques. The most seriously considered dimensions are described below.

1. Unit of analysis. This dimension refers to the level of the target system being measured. The dimension ranges from the micro-individual productivity to macro-national or even world productivity.

2. Scope of measurement. Productivity measurement as operationalized is not a continuous variable. It consists of discrete "snapshots" of productivity at certain time intervals. This dimension simply refers to the length of time between these intervals. It may range from seconds to years.

3. Functional Discipline. There is a close relationship between measurement methods and the academic discipline which developed or which uses the

approach. This is a nominal variable and might have "values" such as economist, manager, accountant, industrial psychologist, or industrial engineer.

4. Type of technology. Some writers argue that the criteria that are appropriate for measuring organizational performance vary as a function of the type of technology employed by the organizational system. Various classifications have been suggested for the technology dimension, however, in general, this dimension ranges from a manufacturing technology (inputs and outputs are invariant) to a service technology where input and output variability are high.

5. Degree of measurability. Measurability refers to the extent to which inputs and outputs in the target organizational system lend themselves to quantification. Systems which transform physical inputs to physical units of output (e.g., machine shop) would be high on this dimension. Systems which transform inputs that are largely intangible to intangible outputs (e.g., law firm or mental health clinic) would be low in this dimension.

Following an analysis of each of these dimensions in light of the assumptions stated earlier, the researchers selected two dimensions to form the taxonomy. These are unit of analysis and scope of measurement. Functional discipline was ruled out because it added relatively little new information to the unit of analysis dimension. Figure 4.1 depicts this relationship. While there is a range of measurement techniques associated with each functional discipline, the central tendency of these distributions leads to a ranking similar to organizational level. Industrial engineering traditionally has been associated with measurement techniques at the individual and small group level as have industrial psychologists. Economists, on the other hand, have tended to focus on more macro measurement techniques useful at the firm, industry or national economy levels.

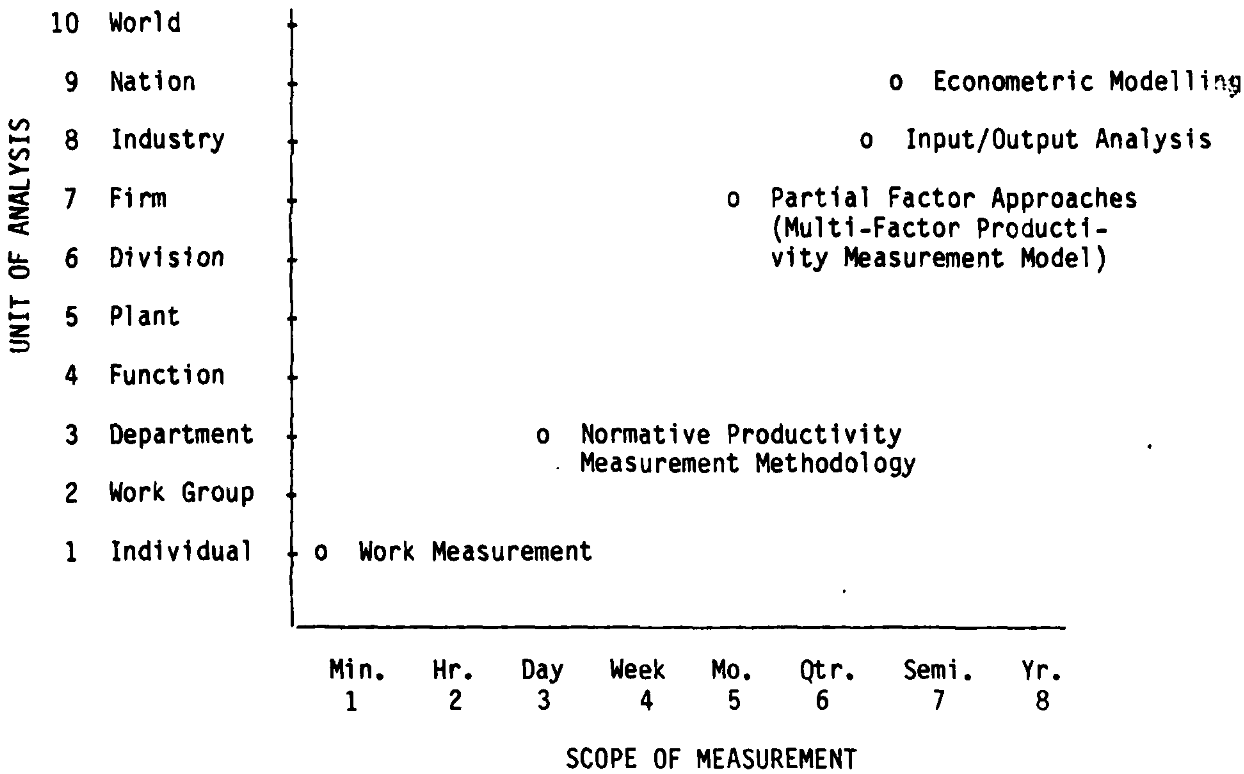

FIGURE 4.1 TAXONOMY DESIGN

Type of technology was not selected as a primary variable for the taxonomy in order to keep the taxonomy simple. If a third dimension were added, type of technology would be the most likely candidate. For present purposes, type of technology will be considered a moderator variable.

The final dimension seriously considered was degree of measurability. This dimension closely resembles the type of technology dimension. In general, systems in which inputs and outputs show low variability, have high measureability. Where the technology is such that variable inputs are converted into outputs which also show high variability, measurement is more difficult and costly. Thus, at this end of the technology dimension, measurability would be low.

C. TAXONOMY DESCRIPTION.

The dimensions selected lead to a two dimensional taxonomy depicted in Figure 4.2 Shaded in cells indicate combinations of the two dimensions which are theoretically possible but operationally make little sense. As a functional taxonomy, it is possible to indicate the appropriate cell or cells in which particular measurement techniques fall. It will then be possible for a manager to select a technique or techniques which meet his/her specifications regarding unit of analysis and scope of measurement. For example, if a manager desires a measurement technique which is appropriate for the plant level and which covers a monthly time period, then the cell indicated in Figure 4.2 would contain the appropriate techniques.

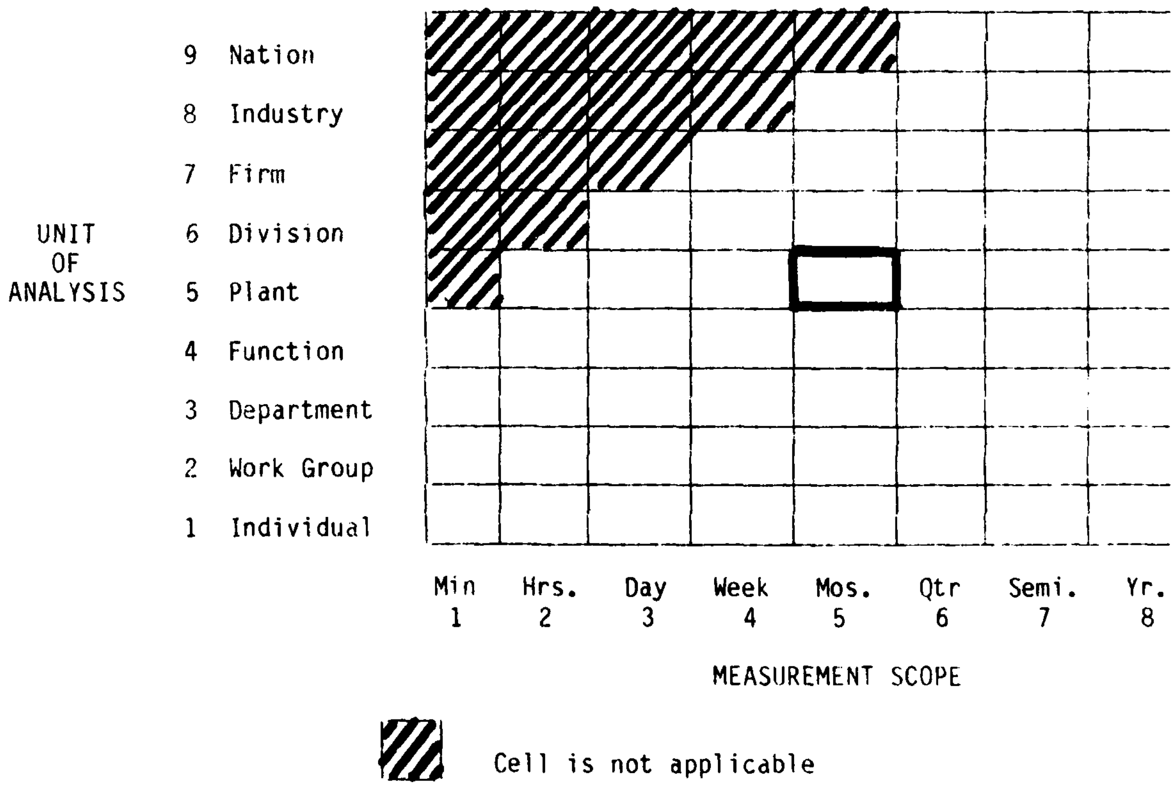

FIGURE 4.2. TAXONOMY OF PRODUCTIVITY THEORIES & TECHNIQUES

This is quite straight forward. However, the selection of a measurement technique is more complex. Using the taxonomy will put the manager in the "ballpark," however some additional "fine tuning" is necessary in order to settle on a particular approach. The "fine tuning" takes place by considering a range of moderator variables. Each of the moderator variables represent considerations which will alter the content or form of the productivity measure depending on the circumstances.

D. MODERATOR VARIABLES.

A wide range of moderator variables were considered, although the researchers believe that those listed below are the most significant. Each moderator variable is defined and the nature of its impact on the measurement technique is briefly noted.

1. Output variability. The extent to which the physical characteristics of the system outputs change over time. If the number of outputs or the type of outputs changes dramatically during a given time period, then the scope of measurement must be increased until a stable time period is identified. For example, suppose there is wide variability from month to month but, on the average, the same products are made every year. In this case the scope of measurement should be annual. When no time period can be found, in which the output mix is stable, physical units must be converted to another unit of measurement, often dollars, to facilitate aggregation and analysis.

2. Process cycle time. How long does it take for one unit of output to be produced. For airplane manufacturing, the cycle time may be months, for printed circuit boards, the time may be seconds or minutes. This moderating variable will affect the choice of the scope of measurement. Generally the slower the cycle time the larger the scope. In addition, for a long cycle time (e.g.,

months) if one desires a measure with a short scope (e.g., hours) then one must move to a low unit of analysis (e.g., individual or work group).

3. Resource as a Percent of costs. In selecting a productivity measurement methodology, feasibility and cost are major concerns. Generally the importance of measurement increases as the resource increases as a percentage of total costs. In a manufacturing process where energy inputs represent 0.1% of total dollar costs, it is not desirable to spend much money tracking energy inputs. However, if energy inputs account for 25% of total costs, the importance of measuring energy inputs increases dramatically.

4. Intended purpose and user of the measure. The selection of a measurement method is in large part a function of what the measure is supposed to do and who will use it. For example, if a measurement technique is to be used in the validation of IMIP savings its audience ultimately is DOD auditors. To satisfy this audience, measures must relate to costs and be stated in dollars, and apply to the function or plant unit of analysis. On the other hand, measures intended to help management improve the productivity of its operations would best be stated in physical unit terms and apply to lower levels of the organization.

5. Controlability of inputs. The extent to which management can "manage" or control input levels affects what is measured. In general, one should focus limited measurement resources on those inputs which can be controlled.

6. Control system maturity. The extent to which measurement and control systems are part of the organizational culture. The major impact of this moderator variable comes in the pace and difficulty of implementing measurement systems. Where measurement systems have not been widely applied, their use should be accompanied by an extensive training process to enable those being

measured to understand the purpose, use and operation of the measurement system. Ideally, these individuals will also participate in its development.

7. Management style. Management styles are typically characterized as autocratic, democratic, or laissez-faire. However, it is rarely possible to classify a management style quite so simplistically. The same manager may be autocratic in certain situations and democratic in other situations. Nevertheless these tend to be dominant styles in most organizational settings. Measurement techniques are most effective when they augment and complement the existing management style. For example, an authoritarian, top-down, organization should think very carefully before implementing a "bottoms-up" measurement approach. If the organization is willing to modify its management style, then introduction of a bottoms-up participative measurement program may be a good way to start. But this decision should be made explicitly, not implicitly through the choice of a measurement method that unknowingly conflicts with the existing management style.

8. Commitment to measurement. The extent to which the organization sees productivity measurement as a critical part of its effort to remain competitive and survive as an organization. If commitment is high, then any method can be made to work. If this is low, few approaches will work and investment in measurement is probably wasted effort.

9. Decentralization/centralization issue (control). The extent to which measurement is a centralized function requiring each operating unit to report to "headquarters" versus a decentralized function where managers create data exclusively for their own use. This variable affects the acceptance of the measurement system and the incentive to "game" the system. Any measurement system can be "gamed." In general, acceptance is greater by managers if the

system is decentralized. However, this is complex and also depends on past history and management style. If centralized reporting has been used in the past to "embarass" or to "beat up" on low producers it will usually meet with resistance. However, if centralized reporting is used as a guideline, if gentle pressure is applied, and if the data is interpreted and used by higher headquarters with judgment, then centralized systems are more acceptable. Probably the optimal system has a blend of centralization/decentralization. Managers must report some indices upward, but most are kept for their own use.

10. Management understanding/awareness. Ultimately, the success of many productivity measurement systems depends on the level of management understanding and awareness as to why it is important to the company, to his/her unit and to him/her personally. If this level of understanding has not been thoroughly ingrained and reinforced repeatedly, the best measurement system will fail!

E. TAXONOMY VALIDATION.

As a means of validating the taxonomy, the researchers conducted field investigations of measurement systems in use by a range of organizations. These actual systems provide a convenient means of assessing the utility of the taxonomy in describing differences between these measurement systems. In this exercise, the taxonomy validation refers to the validity of the dimension and moderator variables in accounting for the major characteristics of the measurement systems. First, Chapter V describes the measurement techniques currently available, and then Chapter VI describes applications of these measurement techniques using the taxonomy variables.

CHAPTER V

PRODUCTIVITY MEASUREMENT TECHNIQUES

A. INTRODUCTION.

A major objective of this project was to identify a comprehensive set of productivity measurement techniques. Those identified to date are described here. While only a few techniques have potential use directly in IMIP, all have potential use by defense contractors to improve productivity and reduce weapon system cost.

As the project progressed, it became evident that a fundamental distinction was necessary among the techniques identified. One set of techniques included those that measured productivity per se; and the second set included those techniques that measured productivity improvements or related factors but not necessarily productivity as defined in Chapter II. The techniques in this second group are referred to as surrogate productivity measurement techniques.

Three different techniques were identified as actual productivity measurement techniques. They are the multi-factor productivity measurement model, the normative productivity measurement methodology, and the multi-criteria performance/productivity measurement technique. Also described in this chapter are the following surrogate techniques:

1. Managing "Productivity" By Objectives
2. IBM Common Staffing Study
3. Micro-measurement approaches
4. Macro-measurement approaches
5. Audits and checklists
6. IMIP validation and verification measurement techniques.

B. PRODUCTIVITY MEASUREMENT TECHNIQUES.

Each of the three productivity measurement techniques is described in enough detail to provide a basic understanding of the technique but not in enough detail to implement it. The references provided for each should be checked if more information is needed. Much of this chapter is exerpted from Sink and Tuttle (1983).

1. Multi Factor Productivity Measurement Model (MFPMM).

In 1955, Hiram Davis, in his book titled Productivity Accounting, described his attempts of measuring productivity at the firm level. Since then the MFPMM has evolved into a price weighted, accounting based model that provides productivity information on various inputs and outputs and relates it directly to profitability.

The MFPMM is a dynamic, aggregated, indexed, and computerized approach to measuring productivity which strictly adheres to the definitions provided in Chapter II. This approach is very similar to other approaches which can be found in the literature: "Total Productivity Measurement" (Craig and Harris, 1973); "The Total Performance Measurement System" (APC, 1978); "The Product-Oriented Total Productivity Model" (Samanth and Hassan, 1980); and "Total Factor Productivity Measurement" (Van Loggerenberg and Cucchiaro, 1981-1982). The MFPMM and the other approaches mentioned essentially blend the major inputs of a particular organizational system together and relate the resulting aggregate input to the total output of that same system. The five basic classes of input resources typically considered are: labor, materials, energy, capital, and services.

The MFPMM can be utilized to measure productivity change in any of these input resources and to measure the effects of these changes separately as well as in aggregate and the corresponding change in profitability. As Van Loggerenberg and Cucchiaro (1981-1982) point out, this technique can be used to:

(a) monitor historical productivity performance and measure how much, in dollars, profits were affected by productivity growth or decline;

(b) evaluate company profit plans to determine whether the productivity changes implied by their plans are overly ambitious, reasonable, or not sufficiently ambitious; and

(c) measure the extent to which the firm's productivity performance is strengthening or weakening its overall competitive position relative to its peers.

With essentially the same basic accounting data used to calculate revenues and costs, it is possible with the MFPMM to gain additional and more detailed insight into precisely which factors are most significantly affecting profits.

a. Methodology. The MFPMM is based on the premise that profitability is a function of productivity and price recovery; that is, an organizational system can generate profit growth from productivity improvement and/or from price recovery. Productivity, as pointed out earlier, relates to quantities ties of output and quantities of inputs, while price recovery relates to prices of output and cost of inputs. Price recovery can be thought of as the degree to which input cost increases are passed on to the customer in the form of higher output prices. The relationship between productivity, profitability, and price recovery is depicted in Figure 5.1. (adapted from Van Loggerenberg and Cucchiaro, 1981-1982).

The data required for the MFPMM are periodic data for quantity and price of each output and input of the organizational system being analyzed. Since value equals quantity times price (V=QxP), having two of the quantity, price, and value variables obviously yields the third algebraically. Quantity, price, and/or value of the various outputs produced and most of the inputs consumed are straightforward and should be provided by most basic accounting systems.

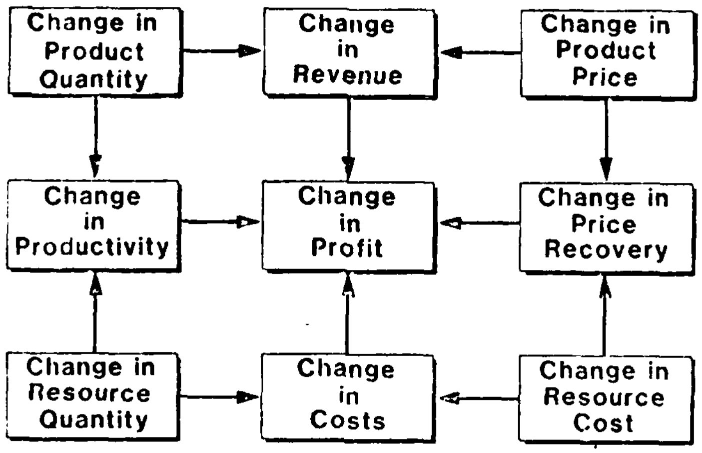

FIGURE 5.1 RELATIONSHIP BETWEEN PRODUCTIVITY, PROFITABILITY, AND PRICE RECOVERY

The output and input data must be entered for two time periods: a base period (period 1) and a current period (period 2). The choice of a base period is a critical decision since it establishes the period against which the current period will be compared. Therefore, the base period should be as representative of normal business conditions as possible. If the data exists, a base period could also be used for "standards" or a budget. Depending upon the needs of the user, the availability of data, product cycle time, etc., period length could be a week, a quarter, a year, or any other period for which input data can be matched to output data.

Table 5.1 depicts the basic format of the MFPMM as it currently exists.

TABLE 5.1 MULTI FACTOR PRODUCTIVITY MEASUREMENT
OSU/OPC VERSION

	PERIOD 1			PERIOD 2			WEIGHTED CHANGE RATIOS			COST/REVENUE RATIOS		WEIGHTED PERFORMANCE INDEXES			TOTAL EFFECTS ON PROFITS		
	QUANTITY, Q_{i1}	PRICE, P_{i1}	VALUE, $(Q_{i1})(P_{i1})$	QUANTITY, Q_{i2}	PRICE, P_{i2}	VALUE, $(Q_{i2})(P_{i2})$	$\frac{Q_2P_1}{Q_1P_1}$	$\frac{Q_2P_2}{Q_2P_1}$	$\frac{Q_2P_2}{Q_1P_1}$	$\frac{\Sigma(Q_{i1})(P_{i1})}{I_{i1}}$	$\frac{\Sigma(Q_{i2})(P_{i2})}{I_{i2}}$	CHANGE IN PRODUCTIVITY	CHANGE IN PRICE RECOVERY	CHANGE IN PROFITABILITY	CHANGE IN PRODUCTIVITY	CHANGE IN PRICE RECOVERY	CHANGE IN PROFITABILITY
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
OUTPUT(S) O_i ... n																	
ΣO_i																	
INPUT(S) LABOR I_L																	
ΣI_L																	
MATERIAL I_M																	
ΣI_M																	
ENERGY I_E																	
ΣI_E																	
INVESTMENT I_I																	
ΣI_I																	
SERVICES I_S																	
ΣI_S																	
ETC																	
[illegible] Σ																	
[illegible]																	

b. Implementation. The MFPMM is most appropriate at the firm and plant level and would be most useful to senior management. The data required to run the MFPMM are quantity and price for each output and input of the entity being analyzed. In order for the model to be used effectively, output and input data must be reliable and consistent over the intended period of time so as to allow valid comparisons from year to year, quarter to quarter, or month to month. The outputs and inputs selected for a given organizational system must be relevant to that system and must include all important factors pertaining to the production or service of that particular system.

A base period should be selected that reflects normal business conditions as closely as possible. The period selected should also be current enough that price and cost data are available for products currently in production or services currently offered. If this is not the case, estimates can be determined for the base period using average market prices, deflators, or estimation based on similar products or services. Since the MFPMM utilizes base-period price weighting, the deletion of old products or services does not present a problem. Conventions should be established at the outset for dealing with output and input measurements that cross period boundaries. For example, a unit started in one period and finished in another would result in fractional measures in each period.

Many other problems not discussed here are addressed in the literature. Davis is an excellent source to consult on revaluation and related problems. Shifts in input cost lines, revaluing new qualities, capital goods revaluation management input, investor input, taxes, depreciation, etc., are all called out and addressed. The treatment of potential problems such as these, as well as others not mentioned, should be resolved by an organization before it begins data collection. Each organization will face unique problems and it must be prepared to deal with them for the MFPMM to work effectively.

It is very important that the MFPMM be closely interrelated with the organization's existing control systems. Managers should be able to use the MFPMM to complement other sources of financial data when making business decisions. Also critical to successful MFPMM application is the degree to which management accepts and feels comfortable with the model and the information it provides.

It is estimated that somewhere between 50 and 100 organizations in the United States are utilizing the multi-factor productivity measurement approach. Among these are: Phillips Petroleum Company, Anderson Clayton, General Foods, Hershey Foods, Sentry Insurance, John Deere, and Federal Express.

As an accounting based model that directly identifies cost and productivity impacts, the MFPMM is an appealing candidate for IMIP. The model has already been implemented in numerous commercial organizations. It appears that MFPMM implementation would cause minimal disruption in existing accounting systems and provide the kind of information required to IMIP negotiations. Testing the MFPMM in a defense environment is necessary before it could be accepted as an IMIP methodology.

2. Normative Productivity Measurement Methodology (NPMM).

Since 1960, industry has spent about $25,000 for every blue collar employee to improve productivity in the factory; however, at a time when the role of white collar workers in industrial operations is expanding dramatically, industry has spent only $2,500 for every white collar employee to improve productivity (Rowe, 1981). Corresponding to the relative amount of resources spent on each group of workers, blue collar productivity has increased dramatically, while white collar productivity improvement has been almost non-existent. Defining the nature and value of white collar contributions, matching the timing of inputs to outputs, and determining both quantity and quality dimensions, are all major stumbling blocks for identifying productivity measures and opportunities for productivity improvement of white collar employees (Ruch, 1980). In hopes of developing a white collar productivity measurement and improvement system, the Normative Productivity Measurement Methodology (NPMM) was developed. Once white collar productivity can be measured, steps can be taken to improve it.

The NPMM was designed, developed and tested at the Ohio State University by the Productivity Research Group of the Industrial and Systems Engineering Department during the period 1975-1978. The basic and early methodology, as tested at Ohio State, incorporated structured group processes to identify appropriate productivity measures for such work groups as engineering, marketing and personnel. The structured group processes are used as mechanisms for shaping consensus and for developing a commitment for further follow-through (Sink, 1981). Once the productivity measures are identified, it becomes the task of the group to operationalize and implement the productivity measurement system. The final and perhaps most important task of the NPMM is to provide feedback to the workers in hopes of identifying productivity improvement opportunities.

a. Methodology. The Normative Productivity Measurement Methodology, as a component of a productivity measurement system, is shown in figure 5.2. As illustrated, NPMM is not implemented until several necessary preconditions are fulfilled. These necessary preconditions include securing top management support and legitimization, organization, preparation and program leadership all of which help to lay the foundation needed to support the NPMM. Without

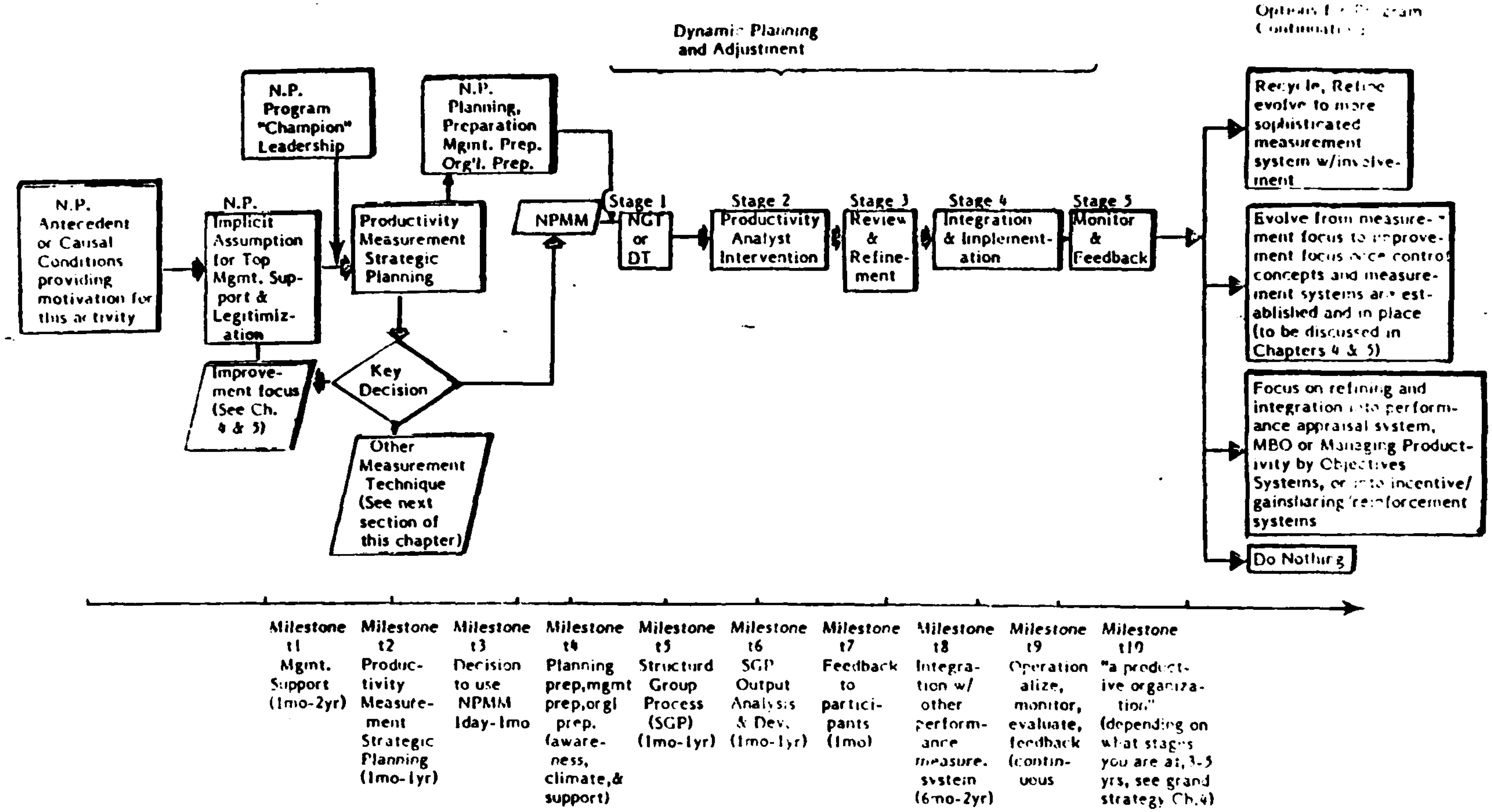

FIGURE 5.2. THE NORMATIVE PRODUCTIVITY MEASUREMENT METHODOLOGY

support from all levels of management and labor, the NPMM cannot be successful. Once it is determined that NPMM is to be used in the productivity measurement system, there are five distinct states to be followed.

b. Implementation. This discussion of the NPMM has focused on generating productivity measures for white collar workers. The reason for this particular focus is due to the difficulty in identifying the components of productivity measures. However, the NPMM can be implemented in any organization that is interested in pursuing a participative method of developing productivity measures. A substantial body of literature and experience relative to participation and group processes suggests that there exists a great amount of untapped resources within organizations in the form of its employees (Sink, 1978). By tapping the resources of its employees, an organization can capture a group wisdom that is most likely to identify the real problem and opportunities involved in productivity improvement. Through worker involvement in the NPMM process, a receptive environment can be created which will be helpful in the actual implementation of any solution to the challenges of productivity improvement (Stewart, 1980).

Once an organization determines that the NPMM will be used to generate productivity measures, it is essential that the level of measurement be identified. It has been determined that the NPMM process functions best when the measurement focus is not on the corporation as a whole, or the individual employee, but upon the individual department. The productivity emphasis, therefore, would be placed upon the "producing" unit. Engineering would be measured for the engineering it produced, marketing for marketing, and personnel for personnel (Rowe, 1981).

The NPMM can be effectively used by defense contractors as a participative approach to productivity measurement, especially for white collar employees, but it cannot be used directly for IMIP purposes. IMIP requires measurement systems that can monitor and verify productivity improvements and can be used in contract negotiations. The NPMM is good for motivating productivity improvements but less useful for verifying improvements.

3. Multi-Criteria Performance/Productivity Measurement Technique (Objectives Matrix).

Performance and even productivity are multi-dimensional issues, factors, and phenomena. In order to completely assess and evaluate the performance and productivity of even the simplest organizational system, it is necessary to measure and evaluate a number of criteria. In the case of productivity, the question becomes one of identifying and determining ratios of output to input. Again, even in the simplest of organizational systems there will likely be multiple outputs and certainly multiple inputs. Two frequent questions arise:

(1) how do we determine which are the most important productivity measures to look at?

(2) how do we combine or aggregate unlike productivity measures so as to obtain an integrated view of changes in productivity over time?

The Multi-Criteria Performance/Productivity Measurement Technique (MCP/PMT or more commonly called the Objectives Matrix) is designed to specifically address these two important questions.

The technique's developmental history rests in the field of Decision Analysis. Research, development and literature in the area of multi-attribute decision analysis and utility theory form the theoretical foundation for this technique. More recently, Stewart in 1979, and Riggs in 1982 have resurrected, simplified and extended previous work into the field of productivity measurement.

If this technique is integrated with the NPMM, then the determination of which measures of productivity to evaluate and how to aggregate them becomes a consultative/participative one. If the technique is developed with insights from management only, then the technique takes on a different, more autocratic perspective. The point is that this technique can be implemented in many different ways depending upon the ultimate purpose.

a. Methodology. Criteria or measures of productivity for the focal organizational system need to be developed. This can be accomplished in a structured participative fashion by persons in the system or in a more expert imposed fashion, again depending upon the ultimate purpose of the measurement system. If acceptance of the ultimate measurement system is critical then a participative approach is recommended. <u>Short</u> term quality/validity of the measurements may result; however, commitment to the goals implicit in the measures and more effective linkage of measurement to improvement is likely. If this is the case, the criteria or measures can be determined in Stage 1 of the NPMM using the Nominal Group Technique (NGT). Stage 2 of the NPMM then becomes application of the MCP/PMT.

One format for this technique is a matrix structure. Riggs and Felix (1983) present this format as their objectives matrix. Figure 5.3 presents an example in the matrix format. A summary of the mechanics of the MCP/PMT are as follows:

1) Identify (a) performance criteria and sub-criteria, and
   (b) productivity ratios to be utilized in the measurement system.

The Nominal Group Technique can be very effective in this step if participation and consensus is desired.

	1	2	3	4	5	6	7	8
Performance Criteria	Effectiveness	Efficiency	Quality	Productivity	Quality of Work Life	Innovation	Profitability, Budget Accountability	Date: Group:
Measures, Ratios, Indexes, Objectives	Accomp. ...	as a % ...	% def. ...	O/I Index ...	Survey ...	#prop. acc. ...	15% ROI Price Rec. ..	
1	5 ...	90% ...	.025 ...	.85 ...	6 ...	75 ...	19% .99 ..	← Actual Performance This Period
2	5 ...	100% ...	0	1.3	10	120	20% 1.0	10
3					9		19%	9
4			.01	1.2	8			8
5	3	90%			7	100		7
6			.02	1.15	6			6
7		80%			5		15%	5
8	2			1.1	4	70		4
9		75%		1.0	3			3
10	1		.03		2	40		2
11				.95	1	10	< .95	1
12	0	< 60%	> .05	< .90	0	< 5	< 15% > 1.1	0
13	10	7	4	0	6	5	9	← Equivalent Score
14	30	5	30	10	10	10	5	← Subjective Weightings
15	300	35	120	0	60	50	45	→ ΣRow15 = 610

Rows 2–12: Performance Scores

Row 13 × Row 14 = Row 15

Performance Indicator ↑ (610)

FIGURE 5.3. PERFORMANCE MEASUREMENT MATRIX
GENERAL FORMAT

2) Rank and rate the criteria. Rank and rate the sub-criteria, measures, ratios, etc. within a given criteria. Place the resultant weightings in the appropriate cells of the matrix or space in the graphical alternative representation.

3) Monitor performance against these criteria. Develop scales for each criteria and/or sub-criteria. Determine an appropriate scale for each. This is actual performance variability against some measurable attribute.

4) Develop a "utility" scale which corresponds to the values developed in step 3 (the scale ranges from 0 to 1.0, 0 to 10 or 0 to 100). In other words, identify a transformation function for one scale (actual performance) to the other scale (utility). A 0 on the utility scale corresponds to unacceptable performance, no performance, etc. A 5 on the utility scale corresponds to minimally acceptable performance. A 10 on the utility scale corresponds to excellent performance.

5) For a given period of time, an analysis period, identify actual performance. Identify the corresponding "utility" or standardized score for the actual level of performance. Place this value in the equivalent score cells in the matrix format. Do this for each criteria and sub-criteria.

6) Multiply equivalent scores times weighting values to get performance values. You can add up all the performance values to obtain an aggregated performance indicator.

7) Track scores over time. Develop control charts.

8) Validate criteria, ranks, weights, utility transformation functions.

9) Evolve into measurement and evaluation systems that promote improvement.

10) Integrate with other performance and productivity measurement systems.

b. Implementation. The challenges to implementing the MCP/PMT focus upon the subjective input required to drive the technique itself. The transformation function and the weights given the criteria are critical parameters of this technique. Identification of the criteria/measures is also a critical and often difficult step requiring some skill. Of course, evaluation, interpretation, and intervention are also critical stages in the application of the MCP/PMT.

The technique perhaps has greatest potential when integrated with the NPMM as a decoupled productivity and/or performance measurement, evaluation, control, and improvement technique. In a decentralized fashion, productivity measurement, evaluation, control, and improvement systems are designed and developed within each organizational system (i.e., work group).

A MCP/PMT could be developed within each unit in an organization. The logic for which criteria/measures are used in the system would reside within the specific organizational systems. At successively higher levels of the organization, attempts would be made to measure and evaluate the overall productivity of subordinate units. These higher levels would therefore have two MCP/PMM systems, one for that specific unit's measurement and evaluation and one or more for the integrated contribution of subordinate units.

The real value in this approach to productivity measurement, particularly if implemented as a stage in the NPMM, is its ability to shape commitment and hence more effectively link improvement efforts to measurement results. Like the NPMM though, it is not going to be a useful validation procedure for IMIP. It may, however, be an approach that can facilitate affective execution of the productivity innovations.

C. SURROGATE PRODUCTIVITY MEASUREMENT TECHNIQUES.

Except for the specific IMIP techniques, the surrogate techniques do not have application directly in IMIP because of their limited scope or inadequacies in monitoring and verifying specific productivity measures. These techniques are only briefly described here, with references given for further information. The IMIP techniques are described in more detail since they have high potential for continued application within DOD.

1. Managing Productivity By Objectives (MPBO).

Managing by Objectives (MBO) has become an accepted managerial strategy. MBO is a formal strategy for translating participation from organization members to a commitment for a common goal. Managing Productivity by Objectives (MPBO) is an adaptation of managing by objectives. MPBO can be thought of as measurement by objectives since productivity closely follows a measurement concept. Paul Mali, author of Improving Total Productivity (1978), is credited with formulating MPBO, and his concepts are presented here.

The framework for the MPBO is a six-step process. Any additional steps are incorporated in one or more of the following main steps:

1) Identify potential areas for productivity improvement. Five areas should be examined for potential productivity improvement. These areas include:

   a. Operations
   b. Responsibilities
   c. Problems
   d. Traditions
   e. Opportunities

2) Quantify Productivity Level Desired. "Before" and "after" new productivity indexes are established in this step.

3) Specify a measurable productivity improvement objective. The new productivity level provides the basis for adapting and setting a productivity objective.

4) Develop plans for attaining the objective. Once a statement of productivity commitment has been made and agreed upon, plans are developed to implement completion of the commitment.

5) Control with milestones of progress toward objectives. This step sets up all activities and tasks on a schedule to measure and report the status of and the progress made toward completing the objective.

6) Evaluate productivity reached. The results of the entire productivity effort are evaluated to see how well objectives have been reached.

2. IBM Common Staffing.

IBM began their "Common Staffing Study" (CSS) on an experimental basis in a manufacturing division eleven years ago. The technique was designed as an attempt to measure/plan/improve productivity in the indirect labor areas. These areas tend to encompass work that is complex, non-repetitive, irregular in character, and often unpredictable. Most traditional work measurement techniques and approaches have been found to be ineffective for these types of application. The CSS is now installed in virtually all major manufacturing plants worldwide in the IBM corporation.

The CSS approach is based on the assumption that it is not feasible nor economical to measure most "indirect" manufacturing jobs in the sense of absolutely determining the minimum requirements, to accomplish a task with "100%" performance. Instead, the objective is to describe the level of productivity, whatever it is, at one point in time, and then to strive to continuously improve that productivity in all areas through future points in time. There are four basic steps to the CSS technique:

(a) define activities,

(b) identify causes,

(c) survey locations, and

(4) data analysis.

CSS is structured in a heirarchy of 14 model functions, activities for each function, and indicators that relate to the activities. Figure 5.4 lists the 14 model functions and gives some typical examples of the associated activities and related indicators.

Indicator ratios are calculated for each plant or measurement area and plotted on one chart for comparison purposes. Points varying substantially from a regression line identify plants and areas with improvement potential.

TYPICAL EXAMPLES

Model Functions (14)	Activities	Indicator
General Services	(8) Secretarial Services	Indirect Manpower
Personnel	(15) Salary Administration	Total Manpower
Finance	(14) Vendor Billing	Purchasing Dollars
Plant Eng. & Maint.	(10) Facility Maintenance	Square Feet
I/S & DP	(9) Computer Operations	Installed Equipment
Production Control	(10) Production Scheduling	No. Machine/Model Types
Procurement	(4) Production Buying	Prod. Purch. Dollars
Mfg. Indirect	(4) Technicians	Direct Manpower
Mfg. Engineering	(16) Tool Design	Tool Dollars
Quality Assurance	(17) Inspection	Inplant Direct Work
Industrial Engineering	(10) Cost Estimating	Value Add Dollars
Materials Distribution	(9) Warehousing	Transactions
Facility Services	(9) Safety	Total Manpower
Product Engineer. (WTC)	(5) Product Support	Part Numbers

FIGURE 5.4. CSS FUNCTIONS AND EXAMPLE ACTIVITIES AND INDICATORS (FROM IBM BRIEFING PACKAGE GIVEN AT AIA CONFERENCES)

CSS is not a total factor productivity index since it addresses only indirect labor. It does not give a precise measurement or quantitative assessment of performance. CSS does provide a relative measure of productivity improvements among plants and areas.

CSS has potential for use by defense contractors in addressing the indirect work areas and in identifying areas with improvement potential. It can not be used directly in IMIP since it addresses only indirect labor and provides only relative measures of labor productivity improvement.

3. Micro-Measurement Approaches.

These surrogate techniques are typically thought of as work measurement procedures. The objective of any work measurement system is to determine the standard time it should take a qualified, properly trained, and experienced worker to perform a specified task or operation when working at a normal pace. This time standard provides a basis for evaluating performance against a set benchmark or goal.

It should be clear that work measures are <u>not</u> the same as productivity measures. Work measures are merely efficiency measures; that is, comparisons of how long it took to complete an activity and how long it should have taken. Productivity, as earlier mentioned, is concerned not only with how long an activity took to complete but also with how much was produced. In other words, productivity is an output and input issue while efficiency is only an input issue.

The more commonly used techniques such as time study, work sampling, and standard data are already being used by defense contractors to control labor costs. MIL-STD 1567 outlines the procedures being following for DOD. Work measurement, by itself, is not adequate to support IMIP negotiations for productivity improvements and related cost reductions, but it certainly can be used to help control labor costs.

4. Macro-Measurement Approaches. Macro-measurement approaches are those concerned with a much larger scope than that needed for IMIP. They typically address industry or national issues such as the Gross National Product (GNP) or the many productivity indexes monitored by the Bureau of Labor Statistics such as output per labor hours. Their value to IMIP is primarily for reference and trend comparisons.

5. Audits and Checklists. Another popular approach to productivity improvement is through the use of audits/checklists. They can serve to identify areas for improvements and to structure an analysis of productivity issues, but they cannot be used by IMIP directly. A number of audits/checklists for designing productivity measurement systems or evaluating the effectiveness of existing efforts are presented in Sink and Tuttle (1983).

6. IMIP Validation and Verification Techniques. The two most popular techniques currently being used to support IMIP negotiations are the Cost Benefit Analysis/Tracking (CBA/T) methodology and the "shared savings" analysis. CBA/T is a specific methodology that assesses manufacturing costs at some baseline and tracks cost changes directly and iteratively as productivity improvements are realized. "Shared savings" is a generic approach that does not address specific productivity indices but bases Return-on-Investment rewards to the contractor upon the differences between a baseline and lower acquisition cost resulting from productivity enhancing investments.

a. Cost Benefit Analysis/Tracking.

CBA/T was developed jointly by Price-Waterhouse and General Dynamics as a means of tracking cost savings from capital investments at the F-16 plant in Ft. Worth, Texas. It is being considered for implementation at additional defense and non-defense manufacturing facilities. CBA/T is a comprehensive approach to measuring and tracking changes in manufacturing cost and productivity. Among many other features, the cost analysis and tracking are integrated and done concurrently and iteratively. CBA/T differs from conventional cost accounting in that costs are treated as direct costs as defined below:

Manufacturing Cost	=	Direct Labor
	+	Direct Material
	+	Machines and Automation
	+	Operational Support
	+	Engineering
	+	Plant and Facilities
	+	Information Systems
	+	Inventory
	+	G&A Support
	+	Finance

CBA/T incorporates a total, top-down factory analysis in a package for effective manufacturing cost management. It is an innovative and comprehensive methodology that refines classical cost classifications while retaining compliance with current DOD cost accounting standards (CAS). Superficial review of the methodology for indirect allocation would cause an appearance of noncompliance with CAS 401 and CAS 402, however a more detailed examination of the accounting technique and costing records discloses no apparent conflict with CAS.

CBA/T is actually comprised of both a Cost-Benefit Analysis Methodology (CBAM) and a Cost-Benefit Tracking Methodology (CBTM). During the course of a "typical" engagement, there is both a CBAM and a CBTM segment. Each segment, in turn, consists of nine work tasks. The CBAM segment begins coincident with the development of a contractor's business plan, or his determination of a need to improve his technology base. The work steps involved in the CBAM segment are:

Step 1: Identify current manufacturing activities. This step develops a model of the contractors current manufacturing functions. The model becomes the basis for the "As Is" portion of a cost-benefit analysis.

Step 2: Quantify current manufacturing costs by function. This step defines the current "cost drivers" and adds cost data to the functional model developed in Step 1.

Step 3: Develop criteria for ranking the improvement potential of each function defined in the Step 2 model. This step provides a methodology for rank-ordering improvement opportunities at the manufacturing function level.

Step 4: Conduct a review of the effectiveness, and thus improvement potential, of existing manufacturing functions. This step results in the rank-ordering, from greatest to least, of the functions where a contractor has an opportunity to reduce, or contain, costs.

Step 5: Identify those manufacturing technologies which could be used to accomplish the improvement opportunities identified in Step 4. This step results in a conceptual design (requirements definition) for various improvement projects. (There may be several improvement projects within a manufacturing function.)

Step 6: Develop the cost-behavior patterns for each potential improvement project. This step adds "costs" and "benefits" to the conceptual design developed in Step 5.

Step 7: Quantify the cost drivers and cost-benefit of each improvement opportunity. Project savings are then determined based on the difference between the cost of proposed processes and current operating costs. This step also provides the "impact" of a project's cost-benefits on the contractor's organizational and financial reporting requirements.

Step 8: Analyze the "risk" associated with each project and assign probabilities for attaining the projected cost-benefits. This step develops a cost-benefit statement, complete with probability of success, for each improvement project.

Step 9: Thoroughly determine the time-phased economics for each improvement opportunity. This step finalizes the cost-benefit analysis and adds return-on-investment data to the statements developed in Step 8. This step produces the "To Be" cost-benefit profile of an improvement project and, combined with other projects, can be directly related to the "As Is" of the functional manufacturing cost model developed in Step 2.

Following the cost-benefit analysis, a typical contractor will proceed with those improvement projects which satisfy their thresholds for return-on-investment, probability of success, and benefit value. For those projects where a decision is made to proceed, it now becomes necessary to track the actual cost-benefits against the anticipated, or planned, cost-benefits. This is the CBTM segment.

The CBTM segment's work steps are:

Step 1: Capture the resulting direct labor cost after the new technology or improvement project is implemented, including: standard direct, learning curve factor, productivity factor, scrap and rework. This step develops the actual direct labor cost baseline.

Step 2: Capture the resulting direct material costs, including: standard direct, yield and scrap. This step develops the actual direct material cost baseline.

Step 3: Capture the resulting value of significant other costs, including: facilities, machinery and equipment, engineering, operations support, indirect labor, indirect material, information systems, inventory carrying costs, general and administrative support, and finances. This step develops the actual indirect cost baselines. Many costs heretofor- considered indirect, can be directly monitored.

Step 4: Based on the data collected in Steps 1, 2 and 3, develop an aggregated actual cost baseline for the improvement project. This baseline includes both those costs directly attributable to the project and the project's share of other contractor operating and support costs.

Step 5: Calculate the difference between the resulting actual cost baseline and the anticipated "To Be" cost baseline developed in the CBAM segment. This step determines the relative cost variance of the project.

Step 6: Reconcile significant variances between the actual and "To Be" baselines, using the documented assumptions developed in the CBAM steps.

Step 7: Revise the predicted "To Be" cost baseline to reflect actual performance, only where appropriate. It is preferable to adjust and tune the technologies until they perform to the specifications as anticipated.

Step 8: Complete the "control loop" by passing the revised "As Is" and "To Be" baselines to the cost-benefit analysis model to determine if new improvement opportunities exist, or if the existing ones should be reprioritized.

Step 9: Report summary information on costs, benefits and comparisons of actual results to predicted results on a reporting cycle that follows both internal and external reporting requirements. This step compiles with general DOD reporting requirements.

The foundation of a cost-benefit engagement is the development of the manufacturing cost model. This model is the tool by which the "As Is" and "To Be" cost behavior patterns of the improvement projects are identified. The model itself consists of a set of assumptions, definitions and economic relationships. Depending on the complexity of the contractor's manufacturing processes and the level of analysis required, the model can be as summarized or as detailed as necessary.

The model provides the framework for quantifying the cost behavior patterns associated with improvement opportunities. The model is structured to ensure that all cost behavior patterns for each improvement opportunity are evaluated. A hierarchy of assumptions and relationships is developed to allow each cost grouping to be successively decomposed into additional detail level subgroupings, depending on data availability and project requirements. Project risk can also be analyzed by assigning a probability distribution to any of the model's variables, depending on their perceived risk factor.

b. Shared Savings.

This generalized approach attempts to identify productivity enhancing investments by contractors and share the resulting acquisition cost savings. DOD receives a reduced acquisition cost, and the contractor earns a desired return on investment through increased profits from the savings. The shared savings approach is compatible with the desires expressed by survey respondents to simply base productivity rewards on the difference between a baseline and some lower acquisition price. It therefore does not require productivity, per se, as the basis for reward. Any form of cost reduction can be accommodated. It has been used as part of the business arrangement negotiated between the Air Force and General Dynamics for F-16 production. A shortcoming is that productivity measurements are not directly addressed. This means the government would have to negotiate using assumptions without access to specific productivity information which may still require validation. The Discounted Cash Flow Shared Saving Model, proposed by the Logistics Management Institute, is one model for analyzing capital investments and associated shared savings rewards.

The discounted cash flow model is merely a year-by-year tracking of all cash flow items, summed to produce net after-tax cash flows. A sample output from the model is presented in Table 5.2 Numerical values employed in the Table are essentially similar to those used in the draft DOD IMIP Guide (Aug 1983) and include a contractor target or hurdle rate of 20 percent. Since many cash flow items require tracking of book value, depreciation and cost-reducing effects of the investment, these items are reproduced for better understanding of the model. The model also calculates contractor IRR without sharing and IRRs to the DOD program and Government. The formal terms used in the model are described next, with numbers corresponding to the line numbers on the output.

1. Investment. The acquisition cost of productive equipment. This input value is used in several calculations. The current treatment is as an equity financed investment, but debt financing can easily be introduced.

2. Shared Savings. Amount of "incentive" added to contract price. The amount is computed to yield a target rate of return to the contractor as explained in separate section below. (See item 14 and the paragraph on shared savings streams.)

3. Imputed CAS 414 Interest. This represents the reimbursable cost imputed in accordance with FAR 31.205-10. (See DOD FAR Supplement 30.70 for measurement of facilities capital in general. For this illustration, the basis for the computation is the net book value, using CAS 409). The applicable interest rate can be selected as an input value.

4. Profit on Facilities. This represents the portion of the weighted guidelines profit objective authorized by DOD FAR Supplement 15.9. The base is the net book value computed in accordance with CAS 409. The rate is to be from 16 percent to 20 percent, and can be varied as an input value.

20% - INTERNAL RATE OF RETURN

TABLE 4.2 IMIP SHARED SAVINGS COMPUTATION
- LMI -

			0	1	2	3	4	5	6	7	8	9
1	INVESTMENT		100.00									
2	SHARED SAVINGS			2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
3	+IMPUTED CAS 414 INTEREST-%	14		13.32	10.99	8.24	5.93	3.99	2.42	1.26	0.49	0.16
4	+PROFIT ON FACILITIES - %	16		17.00	14.12	10.62	7.63	5.13	3.13	1.63	0.63	0.13
5	+CAS 409 DEPRECIATION			11.11	20.83	18.06	15.28	12.50	9.72	6.94	4.17	1.39
6	+PROFIT ON DEPRECIATION - %	8		0.89	1.67	1.44	1.22	1.00	0.78	0.56	0.33	0.11
7	-PROFIT ON SAVINGS - %	12		-3.60	-3.60	-3.60	-3.60	-3.60	-3.60	-3.60	-3.60	-3.60
8	BEFORE TAX CASH FLOW			40.79	46.10	36.96	28.63	21.10	14.65	8.96	4.18	0.29
9	-ACRS DEPRECIATION			-19.00	-30.40	-22.80	-15.20	-7.60	0.00	0.00	0.00	0.00
10	TAXABLE INCOME			21.79	15.70	14.16	13.43	13.50	14.65	8.96	4.18	0.29
11	INCOME TAX - %	46		-10.02	-7.24	-6.51	-6.18	-6.23	-6.73	-4.12	-1.92	-0.13
12	INVESTMENT TAX CREDIT - %	10		10.00								
13	AFTER TAX CASH FLOW			40.77	38.92	30.45	22.45	14.93	7.96	4.86	2.26	0.16
14	DISCOUNT FACTORS IRR - %	20		83.33	69.44	57.87	48.22	40.19	33.49	27.91	23.26	19.38
15	DISCOUNTED CASH FLOW			33.97	27.03	17.62	10.83	6.00	2.66	1.35	0.53	0.03
16	CUMULATIVE DISCOUNTED CASH FLOW			33.97	61.00	78.62	89.45	95.45	98.09	99.44	99.97	100.00
17	PRODUCTIVE SAVINGS AT % 30 W/ INFLATION RATE %	4		30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.36	30.00
18	CONTRACTOR IRR W/O S. S.	17.6 %										
19	DIRECT GOVERNMENT FUNDING		10.00									
20	DOD PROGRAM BENEFIT			-10.79	-16.18	-6.96	1.27	8.82	15.37	21.04	25.82	27.71
21	DOD IRR (%)	15.2 %										
22	TOTAL GOVERNMENT BENEFIT			-10.77	-8.92	-6.49	7.55	13.07	22.10	25.16	27.70	29.84
23	GOVERNMENT IRR (%)	27.7 %										
24	BEGINNING BOOK VALUE			100.00	88.89	68.06	50.00	34.72	22.22	12.50	5.56	1.39
25	-CAS 409 DEPRECIATION			-11.11	-20.83	-18.06	-15.28	-12.50	-9.72	-6.94	-4.17	-1.39
26	ENDING BOOK VALUE			88.89	68.06	50.00	34.72	22.22	12.50	5.56	1.39	0.00
27	AVERAGE BOOK VALUE			94.44	78.47	59.03	42.36	28.47	17.36	9.03	3.47	0.69
28	ACRS DEPRECIATION			19.00	30.40	22.80	15.20	7.60	0.00	0.00	0.00	0.00
29	-CAS 409 DEPRECIATION			-11.11	-20.83	-18.06	-15.28	-12.50	-9.72	-6.94	-4.17	-1.39
30	DIFFERENCE			7.89	9.57	4.74	-0.08	-4.90	-9.72	-6.94	-4.17	-1.39

START BOOK VALUE		100.00	88.89	68.06	50.00	34.72	22.22	12.50	5.56	1.39
ACRS DEPRECIATION BASIS		95.00								
ACRS DEPRECIATION		19.00	30.40	22.80	15.20	7.60	0.00	0.00	0.00	0.00
CAS 409 DEPRECIATION		11.11	20.83	18.06	15.28	12.50	9.72	6.94	4.17	1.39
ENDING BOOK VALUE		88.89	68.06	50.00	34.72	22.22	12.50	5.56	1.39	0.00
AVERAGE BOOK VALUE		94.44	78.47	59.03	42.36	28.47	17.36	9.03	3.47	0.69
IMPUTED INTEREST	14	13.32	10.99	8.24	5.93	3.99	2.42	1.26	0.49	0.16
FACILITIES PROFIT	.16	17.00	14.15	10.62	7.63	5.13	3.13	1.63	0.63	0.13
CAS DEPRECIATION		11.11	20.83	18.06	15.28	12.50	9.72	6.94	4.17	1.39
DEPRECIATION PROFIT	08	0.89	1.67	1.44	1.22	1.00	0.78	0.56	0.33	0.11
PRODUCTIVE SAVINGS INT. RATE(%)	3	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
INF RATE(%)	4									
-SAVINGS PROFIT	12	-3.60	-3.60	-3.60	-3.60	-3.60	-3.60	-3.60	-3.60	-3.59
BEFORE TAX CASH FLOW W/O SHARED SAVINGS		38.62	44.01	34.79	26.46	19.01	12.46	6.79	2.01	-1.88
-ACRS DEPRECIATION		-19.00	-30.40	-22.80	-15.20	-7.60	0.00	0.00	0.00	0.00
TAXABLE INCOME W/O SHARED SAVINGS		19.62	13.61	11.99	11.26	11.41	12.46	6.79	2.01	-1.88
INCOME TAX W/O SHARED SAVINGS	.46	-9.03	-6.26	-5.51	-5.18	-5.25	-5.73	-3.12	-0.93	0.86
INVESTMENT CREDIT	1	10.00								
NET CASH FLOW AFTER TAX W/O SHARED SAVINGS		39.60	37.75	29.27	21.28	13.76	6.73	3.67	1.09	-1.01
DISCOUNT RATE	2	.83333	0.69	0.58	0.48	0.40	0.33	0.28	0.23	0.19
DISCOUNTED CASH FLOW W/O SHARED SAVINGS		33.00	26.22	16.94	10.26	5.53	2.25	1.02	0.25	-0.19

SHARED SAVINGS COMPUTATIONS

	I R	NPV
CONTRACTOR NPV W/O S. SAVINGS	2	95.28
INITIAL INVESTMENT-NPV W/O S SAVING		4.72
DIFFERENCE/(1-TAX RATE)		8.73
CONSTANT PERCENTAGE FACTOR		3.39

METHOD

1	1ST YEAR RETURN	10.50								
2	CONSTANT DISCOUNTED STREAM	1.17	1.40	1.68	2.02	2.42	2.90	3.49	4.18	5.01
3	CONSTANT CASH STREAM	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17	2.17
	PERCENTAGE CASH STREAM	9.67	1.67	1.49	1.99	1.26	0.62	3.39	1.10	-0.69

5. CAS 409 Depreciation. Depreciation expense is an allowable contract cost, under FAR 31.205-11. The amount entered on this line is a function of the service life (amortization period) and the depreciation methods. The calculation is shown in a later section of the report.

6. Profit on Depreciation. Contract costs are used to measure "contractor effort" in developing profit objectives, under DOD FAR Supplement 15.902. Depreciation expense, along with other overhead and general management costs, bear profit at 6 percent to 8 percent. (This portion of the profit objective is reduced by an adjustment to 70 percent of the gross amounts, as provided in 15.902). This profit is entered at its adjusted value.

7. Profit on Savings. The investment in productivity-enhancing equipment is presumed to result in some reduction in manufacturing cost. The saving is likely to be a reduction in manufacturing direct labor. Such cost, if incurred, would have been the basis for profit objective at 5 percent to 9 percent (subject to reduction by the 0.7 adjustment factor). This factor for lost profit can be entered (already adjusted) at the desired rate based on the savings assumed from the productivity gain on line 17.

8. Before Tax Cash Flow. This is a calculated amount, representing the impacts indicated for the first 7 lines. A positive value indicates an increase in cash received by the contractor with the new equipment, as compared with what would have been received without the investment, under the old, higher-cost, production method.

9. ACRS Depreciation. The depreciation expense shown on line 5 is the contract cost, used to determine contract price. this is not necessarily the same amount used by the contractor for income tax purposes, where more rapid writeoff is allowed to compute income for tax purposes. The tax depreciation computation is set out separately in the next item.

10. Taxable Income. This line represents the change in contractor taxable income derived from the changed investment. Formally, taxable income is the sum of all additional revenues received because of the investment (sum of lines 2 through 7) less ACRS depreciation charges used for purposes of computing taxable income under IRS guidelines. A positive number represents an increase in taxable income.

11. Income Tax. The tax rate can be supplied by the user as an input value. The rate represents the marginal rate applicable to an extra dollar of taxable income. The amount displayed is this rate times the amount on line 10.

12. Investment Tax Credit. This reduction in computed tax is allowed only in the first year. It has the effect of increasing the after-tax income.

13. After-Tax Cash Flow. This computed amount shows the net change (after Federal income tax) in the contractor's cash flow for the year because of the investment. A positive number represents an increase in net cash collections.

14. Discount Factor. The present value of any future stream of cash flows can be determined readily when a discount rate is agreed upon. (The "internal rate of return" is the discount rate which will cause a stream of cash flows to have, as its present value, the cost of the investment necessary to product that stream.) The user-provided target return on investment, or hurdle rate, is the discount rate used.

15. Discounted Cash Flow. On this line computed net cash flows for each year are restated in present value terms, at the discount rate supplied.

16. Cumulative Discounted Cash Flow. The values presented on this line are the sums of the present values, starting at the first year and being accumulated. This line is the "scorecard" for the contractor.

17. Productive Savings. The user can supply any desired percentage (of the cost of the new equipment) to represent the cost reduction to be expected each year. If desired, uneven year-by-year precentage savings could be incorporated as a model enhancement. The user may also supply an annual inflation rate, to identify on a year-by-year basis the increasing "then-year" costs to be avoided. The number shown on this line represents the "saved" costs each year, under the given productivity and inflation assumptions. (The inclusion of inflation avoidance savings is controversial and not endorsed by LMI.)

18. Contractor Rate of Return Without Sharing. This calculation shows the return earned by the contractor on his initial investment (line 1) absent any sharing payment. Sharing dollars are then offered, if necessary, to increase the return up to the targeted hurdle rate.

19. Direct Government Funding. This line is provided for the user to input any first year (or prior) cost funded directly by the Government in connection with the investment under consideration. This value will become a part of the analysis of the net value to the Government.

20. DOD Program Benefit. The value on this line indicates the difference between the benefits received by the DOD program (namely, the productivity savings) and the amount paid by the program's budget to the contractor (the before-tax cash flow). Formally, this line represents the difference between lines 8 (before tax cash flow) and line 17 (the productivityinduced dollar savings). Tax effects are not considered because they are not included in the DOD program budget.

21. DOD Internal Rate of Return. The stream of costs and benefits is stated on line 20 in their current amounts. The internal rate of return represents the return to the program which equates the value and timing

of costs to the program with the value and timing of benefits (costs avoided).

22. Total Government Benefit. The numbers on this line display the share allocated to the Government when the savings displayed on line 17 are considered to be available for sharing between the contractor and the Government. The difference between after-tax total to the contractor (line 13) and the total shared benefits available shows the costs avoided or benefit accrued to the Government.

23. Government Internal Rate of Return. The stream of costs and benefits is stated on line 22 in current amounts. The display at line 23 is the discount rate that will make the present value of benefits equal to the costs. This rate is an indication of whether the proposed "deal" is desirable for the Government.

NOTE: The displays beyond this point are detailed, showing the derivations of amounts displayed in the first 23 lines. For most purposes they need not be studied, but they are available to help the analyst to review the results.

The model allows for selection among four shared savings streams, all of which lead to the targeted after-tax return to the contractor. In theory an infinite number of streams to achieve the target IRR are possible. Four shared savings streams currently are available in the model. Except for the first method, all streams cover the entire asset (and program) financial lifetimes. Modification to shorter shared savings profiles is possible.

1. First Year. High enough to front-load the return in the first year (this may not always be possible if funding is from immediate cost avoidance).

2. Constant Discounted Stream. A gross level amount in each year such that the gross level amount when discounted produces even annual discounted amounts.

3. Constant Cash Stream. A gross level amount in each year which when discounted produces uneven discounted cash payments sufficient to yield the target IRR.

4. Percentage Cash Stream. A constant percentage of the pre-sharing cash flow stream which gives the target IRR (comes closest to DOD guide results).

CHAPTER VI

APPLICATIONS OF PRODUCTIVITY MEASUREMENT TECHNIQUES

A. INTRODUCTION.

Although the survey of contractor productivity measurement techniques revealed only implementations of surrogate productivity measurement techniques, a few additional applications were identified during the project research. These known applications are described here using the taxonomy for productivity measurement techniques presented in Chapter V. The applications are of both the productivity measurement techniques per se and the surrogate techniques.

The description of known applications using the taxonomy also serves to validate the taxonomy. Validation refers to the validity of the dimension and moderator variables in explaining the major characteristics of the measurement systems. As shown in this chapter, the taxonomy is useful in describing and comparing the different measurement systems.

Eight applications of the techniques presented in Chapter V are described. Some applications use only one technique; others use some combination of available approaches. These techniques were drawn from the following organizations.

Abbreviation	Name
1. H	Hershey Foods Corporation
2. L	Lockheed-Georgia
3. IBM	IBM
4. Ho	Honeywell - Signal Analysis Center
5. M	Martin Marietta Aerospace - Baltimore Plant
6. G	General Electric Company - Aircraft Engine Business Group

7. W Westinghouse - Manufacturing Systems & Technology Center

8. GD General Dynamics - F-16 Plant

Figure 6.1 presents a classification of the measurement techniques according to the taxonomy dimensions. Each of these techniques is described below in terms of the principal taxonomy dimensions and moderator variables. All descriptions, except for the General Dynamics application, are exerpted from Sink and Tuttle (1983).

B. HERSHEY FOODS CORPORATION - MULTIFACTOR, NORMATIVE AND SURROGATE MODELS.

1. Unit of analysis — 5,6 multifactor model

   2,3,4 *normative and surrogate models*

2. Measurement scope — 8 multifactor model

   4,5 normative and surrogate models

3. Moderator variables

   a. *Type of technology* - system applied to both manufacturing and white collar technologies.

   b. Output variability - low.

   c. Process cycle time - short.

   d. Resources as % of costs - all resources are significant and measured.

   e. Purpose and audience - multifactor model used for overall tracking, planning and evaluating trade-offs in operational decisions; audience is top management. Surrogate and normative models used for diagnostic and improvement purposes by lower and middle management.

   f. Controllability of inputs - all measured inputs are controllable.

UNIT OF ANALYSIS	MIN. 1	HRS. 2	DAYS 3	WEEKS 4	QTR. 5	MOS. 6	SEMI ANNUAL 7	ANNUAL 8
9 NATION								
8 INDUSTRY								
7 FIRM								
6 DIVISION					G	G	G	H G
5 PLANT		H	H G	H G	Ho M G	G	G	H G
4 FUNCTION		H	H G	H G	G	G L	G	IBM G
3 DEPARTMENT			G	G	IBM G	G	G	G
2 WORK GROUP			G	G	G	G	G	G
1 INDIVIDUAL			G	G	G	G	G	G

MEASUREMENT SCOPE

■ CELL IS NOT APPLICABLE

FIGURE 6.1. TAXONOMY OF APPLICATIONS

g. Control system maturity - moderate to high.

h. Management style - not assessed.

i. Commitment to measurement - high commitment by top management.

j. Decentralization/centralization - multifactor measurement model is centralized, not used for control.

Normative/surrogate models are decentralized and used for feedback and control at plant level.

k. Management understanding/awareness - not assessed but is a continuing stated priority of Hershey top management. An ongoing process.

C. <u>LOCKHEED GEORGIA - MULTICRITERIA MODEL</u>

1. <u>Unit of analysis</u> - 4 multicriteria model

2. <u>Measurement scope</u> - 6 multicriteria model

3. <u>Moderator variables</u>

a. Type of technology - system applied to manufacturing, knowledge and white collar technologies.

b. Output variability - moderate.

c. Process cycle time - long.

d. Resources as % of costs - resources measured left to discretion of branch managers.

e. Purpose and audience - primarily for use of branch managers as a guide. Only gross improvement percentage is reported upward.

f. Controllability of inputs - selection of input measures at the discretion of branch managers.

g. Control system maturity - moderate to high.

h. Management style - not assessed.

i. Commitment to measurement - low to moderate, but growing at branch level. Top management commitment not determined.

j. Decentralization/centralization - decentralized.

k. Management understanding/awareness - not assessed but a major priority of Lockheed.

D. IBM - SURROGATE MEASURES, COMMON STAFFING STUDY

1. Unit of analysis - 4 common staffing study (CSS)
   3 surrogate measures

2. Measurement scope - 8 common staffing study
   5 surrogate measures

3. Moderator Variables

a. Type of technology - CSS applied to all indirect areas associated with manufacturing.
   Surrogate measures applied to all functional units (departments).

b. Output variability - low to moderate in manufacturing, moderate to high in indirect areas.

c. Process cycle time - short to moderate depending on produce line.

d. Resources as % of costs - CSS focuses mainly on labor resources. Surrogate measures are not input oriented. Productivity measures not used as resource control system for all inputs.

e. Purpose and audience - CSS is used as a guideline for plant managers, and is viewed by higher management. Surrogate measures are used primarily for the guidance of department managers, however, they are also reported through productivity coordinators to top management.

f. Controllability of inputs - basic premise underlying CSS is that visibility will allow plant managers to identify out of line labor costs and reduce them.

g. Control system maturity - high.

h. Management style - not assessed.

i. Commitment to measurement - high for CSS, commitment to surrogate measures among department managers and top management not assessed.

j. Decentralization/centralization - CSS is highly centralized, top-down system. Surrogate measures are bottom-up systems with low to moderate degrees of centralization.

k. Management understanding/awareness - high on CSS and not assessed with surrogate measures.

E. HONEYWELL SIGNAL ANALYSIS CENTER - NORMATIVE MODEL

1. Unit of analysis - 3,5 normative measurement model

2. Measurement scope - 5 normative measurement model

3. Moderator variables

a. Type of technology - system applied to direct and indirect employees in this mostly white-collar facility.

b. Output variability - moderate to high.

c. Process cycle time - moderate.

d. Resources as % of costs - labor is primary resource and is the one which is targeted for measurement.

e. Purpose and audience - normative model used to guide local managers and to provide overall assessment for division headquarters.

f. Controllability of inputs - all measured inputs are controllable.

g. Control system maturity - moderate.

h. Management style - not assessed.

i. Commitment to measurement - high level at top management levels, middle management levels are not assessed.

j. Decentralization/centralization - system is bottoms-up with general top management support and direction.

k. Management understanding/awareness - moderate to high. This is strong focus of top (division level) management and it has received high, continuing priority.

F. MARTIN MARIETTA AEROSPACE - BALTIMORE PLANT - MULTIFACTOR MODEL

1. Unit of analysis - 5 multifactor model

2. Measurement scope - 5 multifactor model

3. Moderator variables

a. Type of technology - system covers all manufacturing and white collar operations.

b. Output variability - high.

c. Process cycle time - moderate - varies by product category.

d. Resource as % of costs - all resource inputs are measured.

e. Purpose and audience - top management (plant) and division level as an indicator of overall productivity improvement.

f. Controllability of inputs - all inputs measured are controllable at plant manager level.

g. Control system maturity - very highly developed at shop floor level.

h. Management style - not assessed.

i. Commitment to measurement - not assessed.

j. Decentralization/centralization - highly centralized, but used for monitoring primarily.

k. Management understanding/awareness - not assessed.

G. GENERAL ELECTRIC COMPANY AIRCRAFT ENGINE BUSINESS GROUP - IMIP

Measurement

1. Unit of analysis - 6,5,4,3,2

2. Measurement scope - 3,4,5,6,7,8

3. Moderator variables

a. Type of technology - applies primarily to direct employees and manufacturing overhead. The system is also used to monitor indirect employees in relation to their success in controlling shop costs.

b. Output variability - moderate to high.

c. Process cycle time - moderate to high.

d. Resource as % of costs - system measures all shop costs.

e. Purpose and audience - used for the unit manager as a guide and is also used for management control, planning, estimating, and budgeting purposes.

f. Controllability of inputs - units may be measured on inputs they cannot control, although most inputs measured are controllable.

g. Control system maturity - high.

h. Management style - not assessed.

i. Commitment to measurement - very high at all levels.

j. Decentralization/centralization - highly centralized system.

k. Management understanding/awareness - this is a major priority which is carried out through training, performance reviews and linkages with managers pay.

H. WESTINGHOUSE ELECTRIC CORPORATION - MANUFACTURING SYSTEMS & TECHNOLOGY CENTER IMIP MEASUREMENT

1. Unit of analysis - 3,4

2. Measurement scope - 5.

3. Moderator variables

   a. Type of technology - system applied only to manufacturing units.

   b. Output variability - low to moderate.

   c. Process cycle time - very short.

   d. Resources as % of costs - measures labor only.

   e. Purpose and audience - used by department of function manager for cost control, planning, scheduling and estimating.

   f. Controllability of inputs - labor input is controllable.

   g. Control system maturity - moderate.

   h. Management style - not assessed.

   i. Commitment to measurement - not assessed.

   j. Decentralization/centralization - centralized system, data is reported upwards and is used for management control.

   k. Management understanding/awareness - not assessed.

I. GENERAL DYNAMICS - F-16 PLANT, CBA/T

1. Unit of analysis - 3

2. Measurement scope - 4,5,6,7,8

3. Moderator variables

a. Type of technology - applies to all cost contributors in sheet metal department.

b. Output variability - low

c. Process cycle time - short

d. Resource as % of costs - system measures all department costs.

e. Purpose and audience - used for management control, planning, estimating, and budgeting purposes.

f. Controllability of inputs - all inputs

J. SUMMARY.

Based on this limited trial, the taxonomy appears promising as a model for use in classifying and analyzing productivity measurement theories and techniques. It provides a reasonably objective basis to review various measurement schemes in light of a range of organizational characteristics (moderator variables).

The question of the validity of the model for use by managers in selecting measurement techniques must await further testing and experience.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS.

The need to improve productivity within the defense industry is clear. Escalating weapon systems production costs, a deteriorating defense industrial base, and foreign competition provide the unmistakable evidence. DOD's Industrial Modernization Incentives Program (IMIP) was initiatied to address this need by incentivizing defense contractors to improve productivity. This research complements the IMIP effort.

1. Productivity Measurement Practices.

Research conducted to date has identified current contractor productivity measurement practices. Contractors responding to a survey of measurement practices ranked profitability most important on a list of organizational performance evaluation factors. If used at all, productivity was usually ranked fifth, after profitability, effectiveness, quality and efficiency.

Problems encountered by the contractors measuring their productivity were usually due to the complexities of quantifying and relating the various input and output factors involved. Also, meaningful indices were not readily available to identify production productivity impacts on functions other than production.

The respondents indicated a desire to keep any proposed productivity measurement system simple and to base the reward for productivity gains on the cost difference between a baseline and achieved cost, adjusted for inflation. This is basically the way DOD currently attempts productivity measurement and its associated profit reward in the weighted guidelines methodology, but it has not been successfully implemented as currently structured.

There was no evidence of a total factor productivity measurement system implemented by the survey respondents, although some attempts were being made to develop such. Multiple indices were often used; however, they were not integrated as required in a total factor approach. The most popular productivity or performance related indices being tracked by defense contractors were value added/employee and a comparison of standard hours to actual hours for work performed. Some confusion existed as to whether an index was a productivity measurement (i.e., output/input) or some other performance measurement.

Production cost visibility varied widely among the contractors visited, but all could provide direct labor and material costs through work center tracking. Unfortunately, direct costs constitute a small and decreasing percentage of total cost, and therefore are becoming less useful as the sole basis for productivity measurement. Indirect costs are substantial and must also be addressed.

Tracking the impact of an investment for productivity improvement in the indirect areas gets obscured, and these areas frequently increase with a decrease in direct cost. The multiple product, plant and customer environment found at most contractors visited further inhibits accurate cost tracking for productivity measurement. Partly because of the difficulty in tracking the impact of investments in productivity enhancing equipment, the follow-up verification of productivity gains was somewhat lax, especially in the indirect areas.

From the discussions with the contractors visited, it appeared that investments were mostly for competitive and technological reasons rather than simply for cost reduction on the current contract. Contractors tended to plan ahead to other contracts and products and make investments accordingly to improve their long run situation.

2. Productivity Measurement Systems.

This research has also identified a number of available tools to measure productivity and to help bring about required improvements. The report has identified, explained, classified, and evaluated existing productivity measurement practices, theories and techniques. These techniques include both productivity and surrogate measurement systems. Surrogate refers to the fact that productivity improvement efforts (e.g., cost reduction) are being measured rather than productivity directly. Productivity improvement efforts and accomplishments can and are being measured without the aid of productivity measurement and evaluation techniques.

While any of the measurement tools identified can be, and should be used by defense contractors to measure and improve their productivity, only three have the potential to directly complement IMIP. They are the Multi Factor Productivity Measurement Model (MFPMM) and two surrogate techniques - the Cost Benefit Analysis/Cost Benefit Tracking (CBA/T) methodology and the shared savings techniques. Only the MFPMM and CBA/T can provide a basis for contract incentives.

Productivity measurement technology is currently able to provide accurate productivity data to business managers. Although the technology does exist, there are several reasons why industry in general is not taking full advantage of state of the art techniques.

(a) Knowledge of the existence of specific productivity measurement techniques is generally not widespread. The body of industrial engineers productivity managers, and other individuals interested in productivity measurement is growing; however, discussion of productivity methodologies outside this relatively small group is rather limited to the general category of input and output.

(b) The state of the art techniques are less complex than they appear, yet they do require substantial effort to actually implement. Management information systems are required to generate, organize, and interpret data and track productivity improvements. Many smaller organizations might consider gross indicators of cost and output as an acceptable alternative to establishing an entirely new area of effort and personnel devoted to researching and implementing a complex productivity measurement system.

(c) Some of the macro-measurement and other surrogate techniques may be adequate for individual manager's needs. Small job-shop operations, speciality business, and other low volume or lesser complex organizations do not require the elaborate measurement techniques that a large, complex, multi product, high-volume organization requires to remain competitive.

The above comments are as appropriate for a defense contractor as they are for industry in general. Results of the industry survey indicate that productivity factors were ranked low relative to other measures of organizational performance. The defense contractors' inattention to productivity measurement is understandable for two reasons.

(1) Defense contractors are generally not motivated to improve productivity because productivity improvements reduce cost and defense contractor profit opportunity is cost based. As long as this negative incentive exists, contractors cannot be expected to voluntarily initiate a unilateral program to improve productivity. As one attendee remarked at the 1984 Aerospace Divsiion Conference of IIE, the government's profit policy has "incentivized contractors into stagnation."

(2) State of the art productivity measurement methodologies require data analysis. Existing management information systems may not be sufficient to provide the data required in terms of type, degree, or format. One example is the indirect cost contribution of a new item of capital equipment to one of many products or other cost objectives. Absent specific government direction with corresponding consideration, it is not reasonable to expect defense contractors to initiate changes to accounting systems and information systems in order to implement a productivity measurement system. Especially if the end result is a reduction of their cost base for profit opportunity.

3. Implications for IMIP.

In addition to identifying the above techniques, a number of insights were gained that impact application of productivity measurement systems in IMIP. First, it is important that any system address indirect as well as direct costs. Indirect costs such as for "information workers" constitute a large and increasing percentage of total contract cost and must be assessed directly rather than through burdening mechanisms on direct costs.

Current cost and financial accounting systems are not directly providing the cost visibility required for productivity control. It is important that productivity be related to profit and production managers use productivity information feedback to manage and to direct changes and improvements. It may be that either minor restructuring of expense accounts or simply tracking and extracting pertinent cost factors through the more sophisticated cost accounting systems will provide the desired visibility. The production costs are the same - they are just sliced differently to reflect specifically where costs occur and to show how they change.

The degree of change required to provide the cost visibility depends on the existing accounting system and desired visibility. The MFPMM, which is already accounting system based, can provide the desired visibility depending upon the input and output factors selected for tracking. While the CBA/T methodology presents a new accounting perspective, it is not necessarily incompatible with classical accounting. If radical restructuring is not possible or desired, templates or links could be established to extract the cost information from existing systems into a format more suitable for productivity and production cost analysis.

DOD's focus on contractor productivity is best made at the macro level of profitability and productivity as it relates to specific contracts. The micro look at cause and effect of productivity changes from period to period should be left to the contractor. That does not mean the productivity measurement system must attempt to address all factors of production. This may become too complex and costly to maintain. Rather, an attempt should be made to minimize the cost of the measurement and tracking while considering the benefits received. The system should, though, be detailed enough to accurately identify areas for and impacts of productivity changes.

Although the defense industry in general is not motivated to take advantage of state of the art productivity measurement techniques, contractors operating under (or considering involvement with) IMIP procedures are highly motivated. The IMIP provides for sharing of cost savings due to productivity improvements. Measurement and tracking are crucial to credible develoment of the amount of savings to be shared. Since profit in this case is not cost based in the traditional manner, contractors are not negatively incentivized. Additionally, the implementation of a productivity measurement system or methodology in itself should be considered a productivity improvement. The cost to implement a system could be treated as an initial offset from calculated savings prior to sharing, and the maintenance of the system could be treated as an indirect expense. As a minimum the implementation should be negotiable for on-going programs and considered in the business arrangement for new entrants to IMIP.

Since techniques are available to measure productivity improvements, the issue of concern to IMIP is which technique or combination of techniques will provide data to satisfy both the government and industry.

B. RECOMMENDATIONS.

1. DOD should test the following selected techniques in a defense contractor environment:

(a) Multi Factor Productivity Measurement Model

(b) Cost Benefit Analysis/Tracking Methodology

(c) Shared Savings Techniques

The tests should be conducted at multiple sites with a paper test preceeding a live test. The tests will serve to verify the applicability of each technique to the defense industry and to surface areas needing correction or enhancement before widespread implementation. The tests also allow for a variety of comparisons among the different techniques in such areas as accuracy, consistency, efficiency, and sufficiency.

2. Recognizing that no single productivity measurement system will meet every DOD and contractor management need for productivity information, it is recommended that criteria be established which a contractor's system must satisfy rather than dictating a universal system that all must adopt. This concept is similar to that used for the Cost/Schedule Control System Criteria (C/SCSC) and allows the contractor considerable production management flexibility.

The criteria will provide the basis for determining whether a contractor's productivity measurement system is aceptable. It will set forth characteristics which a contractor's system must possess and specify the type of information which can be derived from the system. It may be possible that the productivity measurement system criteria could be integrated into a broader information reporting system such as C/SCSC.

3. This research has identified a number of productivity related areas that need further development. Two of particular importance are (a) capacity utilization and how it relates to productivity and (b) productivity measures for indirect labor (i.e., information/knowledge workers). Productivity and efficiency measures for indirect labor are becoming increasing pertinent, yet they are not nearly as well defined as for direct labor.

SELECTED REFERENCES

Adam, E.E., Jr., Hershauer, J.D., & Ruch, W.A. (1978). Measuring the Quality Dimension of Service Productivity. Tempe AZ: Arizona State University.

American Productivity Center, How to Measure Productivity At the Firm Level. Short Course Notebook and Reference Manual. Houston, Texas, 1978.

"APCOMP Performance Measurement System." (no date) American Productivity Center, Houston, Texas 77024, Literature describing system.

Buck, J.T. (June 1984). "The Health, and Illnesses of the U.S. Aerospace Industrial Base Pinpointed in Massive Air Force/Industry Study," Government Executive, Washington, DC.

Campbell, J.P., D.A. Peterson N.G. & Dunnette, M.D. (1974). The Measurement of Organizational Effectiveness: A Review of Relevant Research and Opinion. NPRDC TR 75-1, AD 786 462, San Diego, CA. Navy Personnel Research and Development Center.

"Cost/Benefit Analysis and Cost-Benefit Tracking, A Successful Methodology" (no date). Price Waterhouse, 200 East Randolph Drive, Chicago, IL 60601.

"Cost/Schedule Control Systems Criteria Joint Implementation Guide" (31 March 1972). Departments of the Air Force, the Army, and the Navy. AFSCP/AFCCP 173-5, AMCP 37-5, NAVMAT P5240.

Craig, C.E. and Harris, R.C. (1973, Spring). "Total Productivity Measurement at the Firm Level," Sloan Management Review, pp. 13-29.

Craig, M.R. and H.J. Pousardien (Sep 1982). "Weighted Guidelines: An Empirical Investigation of Research and Development Acquisitions," Air Force Institute of Technology, OH.

Davis, Hiram (1955). Productivity Accounting. Philadelphia, Pennsylvania: The Wharton School, Industrial Research Unit, University of Pennsylvania.

"Discounted Cash Flow Shared Saving Model" (March 1983). Logistics Management Institute, P.O. Box 9489, Washington, DC 20016. Discussion draft.

"DOD Guide Improving Productivity in Defense Contracting (Draft)," (Aug, 1983). DOD, Washington, DC.

Gold, Bela (1983, March). Practical Productivity Analysis for Management: Part I. Analysis Framework. Institute of Industrial Engineers Transactions, 14(4), 227-242.

Gold, Bela (1983, March). Practical Productivity Analysis for Management: Part II. Measurement and Interpretation. Institute of Industrial Engineers Transactions, 15(1), 63-78.

Greenburg, L. (1973). A Practical Guide to Productivity Measurement. Bureau of National Affairs, Washington, D.C.

Hassan, M. Zia, P. Shanthakumar, and David J. Sumanth (no date). "Total Productivity Model User's Manual," Illinois Institute of Technology, Chicago, IL 60616.

Honeywell ADG Guide to Improved Productivity and Quality of Work, (1982). Aerospace and Defense Group, Productivity/Quality Center: Edina, MN.

Hughes Aircraft Company (1978). R&D Productivity Study Report. Culver City, CA.

Kendrick, J.W. and APC Staff (1982). Measuring and Promoting Company Productivity: Handbook with Case Studies. Baltimore: John Hopkins Press.

Kendrick, J.W. and Grossman, E.S. (1980). Productivity in the United States, Baltimore: John Hopkins Press.

Lehrer, R. (Ed.) (1982). White Collar Productivity. New York: McGaw-Hill.

Mahoney, T. & Frost, P.J. (1974). The Role of Technology in Models of Organizational Effectiveness. Organizational Behavior and Human Performance, 11(1).

Mali, Paul (1978). Improving Total Productivity. New York: John Wiley & Sons.

Miller, D.M. (May-June 84). "Profitability = Productivity + Price Recovery," Harvard Business Review, Boston, MA.

Naisbitt, John (1982). Megatrends. New York: Warner Books, Inc.

Norton, M.G. and W.V. Zabel (Oct 1983). "Contractor Productivity Measurement Practices," Army Procurement Research Office, Fort Lee, VA. APRO 83-01.

Oklahoma Productivity Center (1983). A User's Guide to the Multi-Factor Productivity Measurement Model.

"PACER PRICE" (3-4 Aug 83). Proceedings from AFLC PACER PRICE Conference, OC-ALC.

Packer, M.B. (1983, January-February). Analyzing Productivity in R&D Organizations. Research Management, pp. 13-20.

Peters, T.J. & Waterman, R.H., Jr. (1982). In Search of Excellence, Lessons From American's Best-Run Companies. New York: Harper & Row, Publishers.

Price, J.L. (1968). Organizational Effectiveness. Homewood, IL: Irwin.

"Productivity Measurements at IBM." Presentation at Aerospace Industries Association Conference.

"Rethinking the Issue of Productivity" (Oct 1983). Industrial Engineering, Norcross, GA.

Riggs, J.L. and Felix, G.H. (1983). Productivity by Objectives. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Rowe, David L. (1981). Productivity Measurement at the Plant Level. Omega, 9(1), 37-42.

Ruch, William A. (1980). Measuring Knowledge Worker Productivity. Conference on Productivity Research, American Productivity Center.

Sink, D.S. (1983). How to Make the Most of the Nominal Group Technique. National Productivity Review 2(2).

Sink, D.S. (1978). Initiating Productivity Measurement Systems in MIS. 1978 ASQC Technical Conference Transactions, Chicago, IL.

Sink, D.S. (1984). Productivity Management: Measurement, Evaluation and Improvement, to be published with John Wiley & Sons, New York.

Sink, D.S. (1980). Productivity Measurement and Improvement Strategies and Techniques. Seminar Notebook. LINPRIM, Inc. Stillwater, OK.

Sink, D.S., Tuttle, T., DeVries, S., and Swaim, J. (30 Nov 83). "Development of a Taxonomy of Productivity Measurement Tehories and Techniques," Oklahoma Productivity Center, Stillwater, OK.

Skipper, F.M. and R.A. Sniffin. "An Approach to Developing Measures of Staff Productivity," Defense Management Journal, Alexandria, VA. Fourth Quarter 1983.

Stewart, William T. (1978, February). A "Yardstick" for Measuring Productivity. Industrial Engineering, pp. 34-37.

Stewart, William T. (1980). Productivity Measurement of a Common Carrier Freight Company. Proceedings of the Spring Annual Conference, 419-425.

Stimson, R.A. and Reeves, A.D. (1983, July). Improving Defense Contractor Productivity. Defense Management Journal, pp. 41-44.

Stimson, R.A. and Reeves, A.D. (1984, February). Tri-Service DOD Program Provides Incentives for Factory Modernization. Industrial Engineering, pp. 54-61.

Sumanth, D.J. and Einspruch, N.G. (Oct 1980). "Productivity Awareness in the U.S.: A Survey of Some Major Corporations," Industrial Engineering, Norcross, GA.

Sumanth, D.J. & Hassan, M.Z. (1980). Productivity Measurement in Manufacturing Companies by Using a Product-Oriented Total Productivity Model. Proceedings of the Institute of Industrial Engineers Spring Annual Conference, pp. 255-266.

Thor, C.G. (1982). Productivity Measurement. Supplement to Corporate Controller's Manual, Warren, Gorham and Lamont.

Tuttle, T.C. (1981). Productivity Measurement Methods: Classifications, Critique and Implications for the Air Force, AFHRL-TR-81-9. Brooks Air Force Base, Texas, Air Force Human Resources Laboratory.

Van Loggerenberg, B.J. & Cucchiaro, S.J. (1981-82, Winter). Productivity Measurement and the Bottom Line. National Productivity Review 1(1), 87-99.

Zabel, W.V. and M.G. Norton (July 1981). "Requisites for Contractor Productivity Improvement," Army Procurement Research Office, Fort Lee, Virginia 23801. APRO Project 81-03.

APPENDIX

CONTRACTOR PRODUCTIVITY MEASUREMENT SURVEY

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President

4 March 1983

In support of DoD efforts to encourage improved defense contractor productivity, the Army Procurement Research Office (APRO) is examining practical ways of measuring productivity. This letter provides you an opportunity to participate in an effort that will mutually benefit both industry and DoD.

In this regard, on 4 November 1982 the Defense Department announced the test of an Industrial Modernization Incentives Program (IMIP) designed to encourage contractors to make capital investments that will improve their industrial productivity. The incentives to be tested are shared savings rewards, contractor investment (termination) protection, and others which may be appropriate. Development of a practical method of measuring contractor productivity is of importance if certain incentive structures are to be used.

APRO is seeking information about productivity measurement methodologies currently employed by defense contractors, and NSIA has agreed to participate in a survey of its members. While the survey can be completed anonymously, we suggest you identify yourselves for follow-up discussions. Your cooperation in completing and returning this survey to NSIA by 20 April 1983, is solicited.

Sincerely,

L. H. Bosshard
Committee Executive
Procurement Committee

LHB/md
enc.

PRODUCTIVITY MEASUREMENT SURVEY

The Army Procurement Research Office (APRO) is seeking information describing productivity measurement methodologies used by defense contractors. APRO does not want data on actual performance or goals achieved or other potentially sensitive information. Although the survey can be completed anonymously, contractor identification is encouraged in Section E for possible follow-up discussions. Some of the questions require responses on separate paper.

A. GENERAL INFORMATION:

1. Indicate your predominant commodity markets in order of relative importance to your company, (e.g., 1, 2, 3 . . .)

_____ (a) Aircraft

_____ (b) Missile and Space Systems

_____ (c) Ships

_____ (d) Tank-Automotive

_____ (e) Weapons

_____ (f) Ammunition

_____ (g) Electronics and Communication Equipment

_____ (h) Other (Specify)

2. Are you currently involved as a prime or subcontractor on a major weapon system? _____ No _____ Yes

_____ Prime _____ Subcontractor _____ Both

3. State the approximate dollar value of your defense contracts during your last accounting period. _____ Amount _____ Period

4. With which military service did you contract in the last business year? If more than one, indicate the predominant service with a P and check others.

_____ (a) Army

_____ (b) Navy (Marines)

_____ (c) Air Force

_____ (d) Defense Agencies (e.g., DLA, DARPA, etc.)

AD-A146 756 CONTRACTOR PRODUCTIVITY MEASUREMENT(U) ARMY PROCUREMENT RESEARCH OFFICE FORT LEE VA M G NORTON ET AL. JUN 84 APRO-83-01-F 2/2

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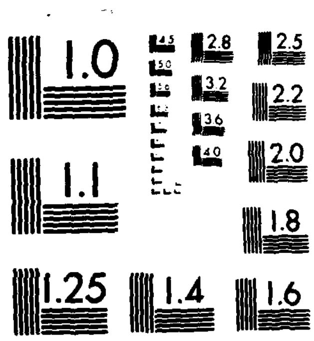

MICROCOPY RESOLUTION TEST CHART
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B. PERFORMANCE EVALUATION (at profit center level or above):

1. Which of the following factors do you use to measure organizational performance within your company? (Indicate order of relative importance to your company, e.g., 1, 2, 3 . . .)

_____ (a) Effectiveness (i.e., accomplishing the right goals or objectives considering timeliness, quantity, and quality)

_____ (b) Efficiency (i.e., ratio of resources expected to be consumed on goal achievement to resources actually consumed)

_____ (c) Quality (i.e., conformance to specifications)

_____ (d) Profitability (i.e., comparison of revenues to costs)

_____ (e) Productivity (i.e., ratio of output to input)

_____ (f) Quality of Working Life (i.e., personnel response to living and working in organization)

_____ (g) Innovation (i.e., introducing new ideas, processes, or products)

_____ (h) Other - (Please specify) ______________________________

2. Describe the specific measures used to evaluate the performance factors identified above. (e.g., for profitability - return on assets employed, return on investment, etc.; for quality - average quality level, number of rework hours, etc.).

3. Describe any problems or shortcomings encountered in using your measures (except for the productivity measure which is to be described in Section C).

4. If you are required to report any of the above or similar measures on a defense contract, please specify.

IF PRODUCTIVITY IS BEING MEASURED, COMPLETE SECTION C, OTHERWISE SKIP TO SECTION D.

C. PRODUCTIVITY MEASUREMENT:

1. For the productivity measures identified in question B.2, specify the level within your company to which each measure applies - program, shop, department, plant, firm, etc.

2. Briefly describe the data sources used to measure and track achievements for each productivity measure.

3. Describe your measurement techniques, including any data adjustments, used for each productivity measure. Data adjustments include such items as inflation, discounting, quantity or quality changes, and learning curve effect.

4. Describe any validation or follow-up actions required to be taken subsequent to implementation of proposed productivity improvements.

5. What problems or shortcomings are encountered in using your productivity measures?

6. Would you be willing to discuss additional details of your productivity measurement methodology with DOD if needed? _____ Yes _____ No (If yes, please complete Section E).

7. If documentation is available describing your productivity measurement procedures, please send a copy to

US Army Materiel Systems Analysis Activity
US Army Procurement Research Office
ATTN: DRXSY-PRO (Project 83-01)
Fort Lee, Virginia 23801

D. COMMENTS:

1. If the Government were to offer your company a productivity incentive in a new contract, how would you prefer to have your productivity improvements measured?

2. Additional information or comments pertinent to this survey would be appreciated. Questions should be referred to either Mr. Monte Norton or Mr. Wayne Zabel, APRO, telephone (804) 734-3896.

E. ORGANIZATION DESCRIPTION (Optional):

1. Company Name and Address:

2. Point of Contact (Name and Telephone):

STUDY TEAM COMPOSITION

Monte G. Norton, P.E., Project Officer, Chief, Test and Evaluation Group, Army Procurement Research Office, Fort Lee, Va. B.S. in Industrial Engineering, North Dakota State University, 1969. M.E., Industrial Engineering, Texas A&M University, 1970. Prior to joining the US Army Procurement Research Office, Mr. Norton was an Industrial Engineer with the US Army Installation Support Activity, Europe and an Operations Research Analyst with the Defense Logsitics Studies Information Exchange (DLSIE). Before that, Mr. Norton was a General Engineer with the Safeguard System Command, Alabama, and has been a Government subcontractor.

Wayne V. Zabel, Procurement Analyst, US Army Procurement Research Office, US Army Materiel Systems Analysis Activity, Fort Lee, Va. B.A. in Economics, 1965, North Park College, IL. M.S. in Procurement and Contract Management, Florida Institute of Technology, 1978. From May 1966-May 1974, Mr. Zabel worked for DCASR, Chicago, as a Contract Administrator; and from May 1974 to May 1977, he was an instructor for the Defense Advanced Procurement Management Course (renamed Management of Defense Acquisition Contract Course (Adv)), at the Army Logistics Management Center, Fort Lee, Va.

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Productivity Measurement

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to develop and test measurement systems designed to complement the DoD Industrial Modernization Incentives Program (IMIP) by providing a productivity measurement and tracking system. The report describes the results of a survey of defense productivity measurement practices and identifies a number of techniques available to measure productivity and to help bring about required improvements. It is recommended that the described measurement techniques be tested in a defense contractor environment. Testing of (1) Multi Factor Productivity Measurement Model (MFPMM), (2) Cost Benefit

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Tracking (CBA/T) Methodology and (3) the shared savings techniques is scheduled to commence in FY 1985 as a contracted effort.